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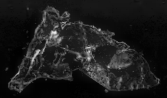

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DEVELOPMENTS IN ELECTRIC TRACTION

By DR. K. SACHS. (From *Schweizerische Bauzeitung*, Vol. 115, No. 15, April 13th, 1940, pp. 167-170.)

ON the Rigi Rack Railway Line recent motor coaches mounted on two four-wheel bogies (Fig. 1) have been built to seat seventy-two passengers, plus 232 Kg. (4.75 cwts.) of luggage, within the total weight of 16.7 tons (metric). Vehicle weight per passenger is approximately one quarter of a ton (0.232 ton).

In this recent design, although the wheel base of each bogie is short, two motors are located between two axles, thus concentrating the weight of motors and gearing near to the bogie swivelling centres, and well within the points of contact between wheel flanges and rails, a provision well known to rolling stock engineers as minimizing the risk of derailment and of flange and rail wear on curves.

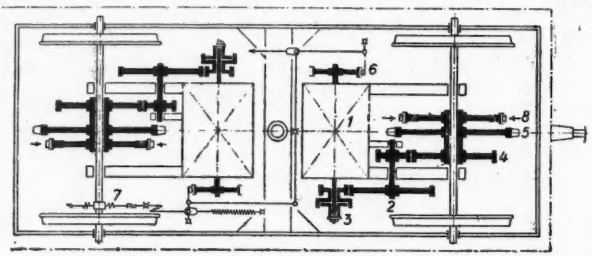


Fig. 1

(1) High gear reduction between motor shafts and bogie axles, with consequent high armature speed.
(2) Brake drums on axles and motor shafts
(3) Stout mechanical construction between gear wheel, rack pinion and axle brake drum, thus relieving the axles of torsional strain at times of heaviest stress when climbing or braking through the rack.
(4) Friction clutches between motor shaft and first train of reduction gear, through which motor load may be steadily applied.

On the Glion-Rochers de Haye railroad motor coaches seating fifty-two passengers with 292 Kg. (5.5 cwts.) of baggage, have been built to run on track gauge 800 mm. (31.5 inches), within a weight of 15.3 tons (metric), thus providing a vehicle weight per passenger of approximately 0.3 tons. Two bogies are provided, each with one motor, which, owing to the narrow gauge, are placed longitudinally on the bogie.

Recently under construction for the Brünig railway were six axled motor vehicles—arranged for operation either separately upon adhesion or rack tracks, or both, simultaneously. They weigh 61 tons (metric), and from Fig. 2 it will be seen that :—

(1) Three two-axle bogies are employed, viz. :—

(a) One in the centre which carries rack pinions and two motors.

(b) One at each end, with one motor to each axle driving adhesion wheels.

(c) The adhesion wheel motors are partially axle borne, and follow normal practice. The four together are rated at 1248 h.p.

(d) The rack pinion motors are together rated at 704 h.p., and follow customary practice in that they are mounted above floor level and within a machine compartment of the vehicle body. These motors are double geared to the rack pinions.

(2) The end compartments are designed as luggage or freight vans.

On the Furka-Oberalpen railway are running motor coaches which provide accommodation for passengers with lavatory compartment, also luggage van (Fig. 3). Two bogies are employed, one only of which is motor driven : two single phase motors together being rated at 430 Kw. hours output. The vehicle weight is 32 tons (metric). The pantograph collector

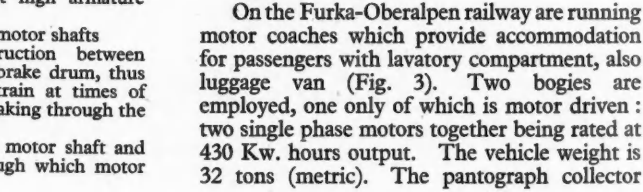


Fig. 2

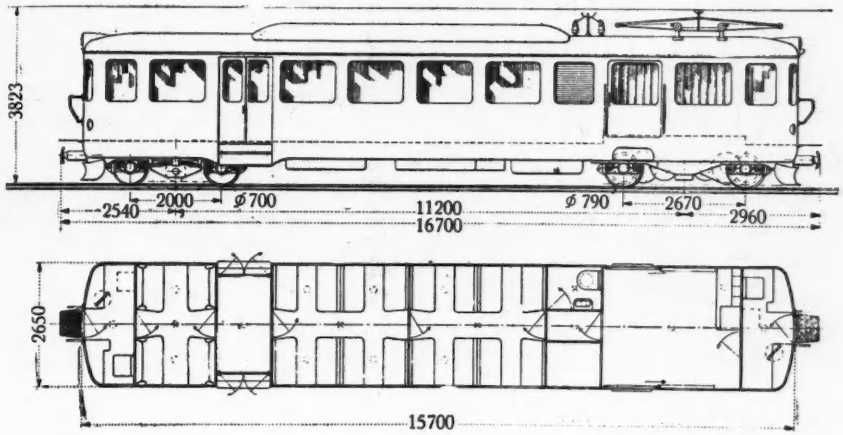


Fig. 3

has been specially designed for high speed working, and combines stiffness with light weight, viz. 190 Kg. (about 3.5 cwts.). The construction embodies stream-line features, tubular framework and stable contact with the overhead conductor.

On the European Continent, unlike that of America, practice for high voltage favours the use of main switches, operated by compressed air, and roof fuses carried on an earthed frame, and between horn-shaped arc gaps.

In place of voltmeters indicating line pressure, which, for accurate reading depend upon good contact between collector and overhead wire, electron tubes are now employed. Fig. 4 shows a diagram of connections from which it will be understood that :—

(1) An aerial is connected to the grid (G) of a thermionic valve.

(2) A supplementary anode (T) provides a fluorescent shade sector of greenish hue when the valve is in operation.

The shape of this shade sector depends upon the potential of the grid over and above the potential of the cathode (K).

If an alternating potential be imposed upon the grid, the shade sector decreases in shape during a negative half alternating period, and in correspondence with the effective voltage value.

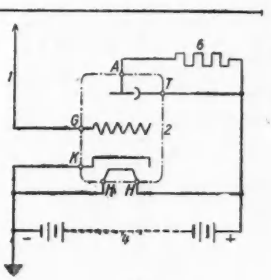


Fig. 4

At higher frequencies the shade sector glows brightly, at lower frequencies it is reduced to a glimmer. Green fluorescence indicates that the apparatus is working; a steady shade indicates zero potential at the overhead line. The arrangement affords a ready means for the driver to ascertain the conditions of energy available to him.

Oil cooled transformers are now general practice on the European Continent, where necessary oil cooling and circulating apparatus is provided, and transformers are placed either between axles or on the roofs of vehicles, together with control apparatus.

Speed regulation of electric vehicles depends largely upon the control equipment.

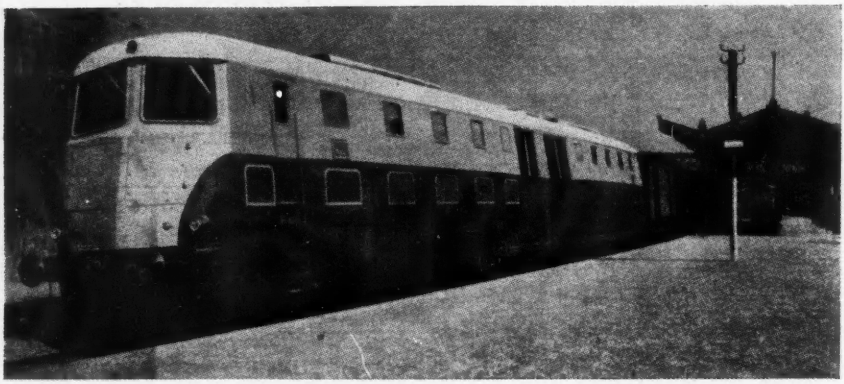


Fig. 5

For those operating on public highways, such as tramcars and trolleybuses, maximum speed is limited by considerations of safety to other traffic. An important factor affecting journey times is the degree of acceleration or retardation which will avoid disturbance to passengers, who will accept increase or decrease of speed up to high limits providing they follow a definite smooth curve and jerking is absent. A common method, whether for starting or stopping, is by stepped control. Though never entirely satisfactory it has been much improved by automatic governing of the movement from step to step. On the American Continent such control has been operated with as many as 292 steps, of which some 18 operate to vary field strength. Following the optimum field strength resistance is cut out step by step, and acceleration up to six feet per second has been obtained. Series parallel control is employed, and for long distance runs where high speed is of long duration, motors run in parallel for much of their operating time. Controllers are frequently operated by Servo Motors, and the acceleration governed by maximum current relays suitably adjusted to the acceleration desired.

For vehicles of light weight of which passenger load represents a considerable fraction of the total weight, and the number of passengers varies widely, non-variable acceleration may be ensured by adding auxiliary windings to the relays, which may be set to suit the ascertained useful loading of the vehicle. Where trailer cars are attached during peak traffic loads and other variable conditions, similar relays may be employed, and hand control virtually relied upon.

Braking by eddy currents may provide uniformly smooth retardation and is employed down to a speed of five miles per hour.

On the European Continent controllers having from 18 to 25 positions are usual, and provide a speed regulation sufficiently uniform for practical working. Employing master controllers and contactors, rheostatic connections up to 21 series, 17 parallel and 20 braking positions are usual. In some cases master controllers are operated by Servo motors.

Certain single phase locomotives in Germany employ similar control apparatus in connection with low voltage transformer tappings. Alternatively, similar results may be attained with high voltage tappings.

On trolleybuses, as on tramways, full automatic speed control is now much in favour, and various types of apparatus for that purpose have been evolved. It must be recognised, however, that entirely stepless speed regulation, following a smooth curve, can be obtained only when a transformer itself will operate steplessly, but generally speaking the effect of a normal number of steps in control proves to be sufficient for luggage and freight vehicles, etc., where passengers are not catered for.

Trolleybuses throughout the world are rapidly increasing, due in a large degree to the greater comfort, higher speed and mobility when working through other traffic, which they offer in comparison with internal com-

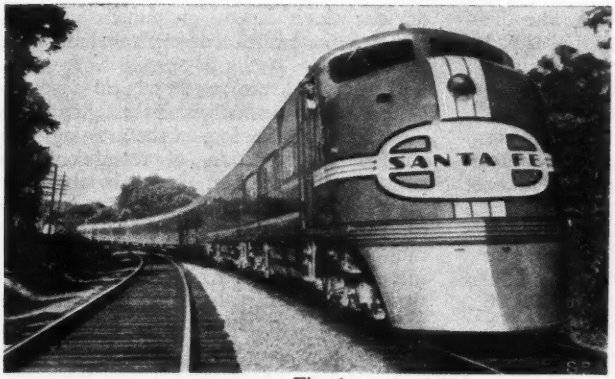


Fig. 6

bustion engine vehicles or tramway cars. These advantages may be further enhanced by switching, controllers and other technical details which characterize modern electric railway locomotives. Speed steps controlled either by hand or automatic controller, but subject to a maximum current relay, are in general use in conjunction with either series, parallel, or parallel motor connections.

Compound wound motors are being employed more generally on trolleybuses than was customary on tramways; they are of more expensive construction, but offer an opportunity for taking such advantages as regenerative control may offer where route contours are favourable.

Diesel-electric locomotives (small and large) as well as motor coaches continue to be built in large numbers (Figs. 5 and 6 show recent examples). Ward-Leonard control is frequently employed, and oil injection controlled by general field strength is a notable feature, presenting the advantage that fuel supply may thus be independent of engine revolutions. Although the incidental design has the advantage of simplicity, such units suffer by reason of that characteristic of Diesel engines which compels the employment of over dimensioned units to avoid overloading.

A recent example of steam turbine electric locomotive appeared in America (Union Pacific Railroad). The designed output is 5000 h.p. and the total weight 480 tons. In principle this bears resemblance to the Heilman locomotive originated in the early days of electric traction on railways.

A very interesting development in Europe is that of a gas-turbine-electric locomotive. Compressed air is delivered to a combustion chamber, and there gases are heated to 550 degrees Centigrade by an oil flame. These hot gases operate the turbine, to which are connected electric generators and compressor. Warm exhaust passes through a preheater, by which the temperature of air for the compressor is raised. It is claimed that for an output of 1,000 K.w. from such locomotives, the weight of fuel they need to carry should not exceed 550 Kg. (say 10.75 cwts.), whereas for the same output a steam locomotive may have to carry 12 tons of water in addition to 125 Kg. (say 2.25 cwts.) of fuel.

AVIATION'S "RUBBER STAMP"

By HENRY E. GUERIN, Factory Superintendent, Douglas Aircraft Company.
(From *American Machinist*, April 3 and 17, 1940).

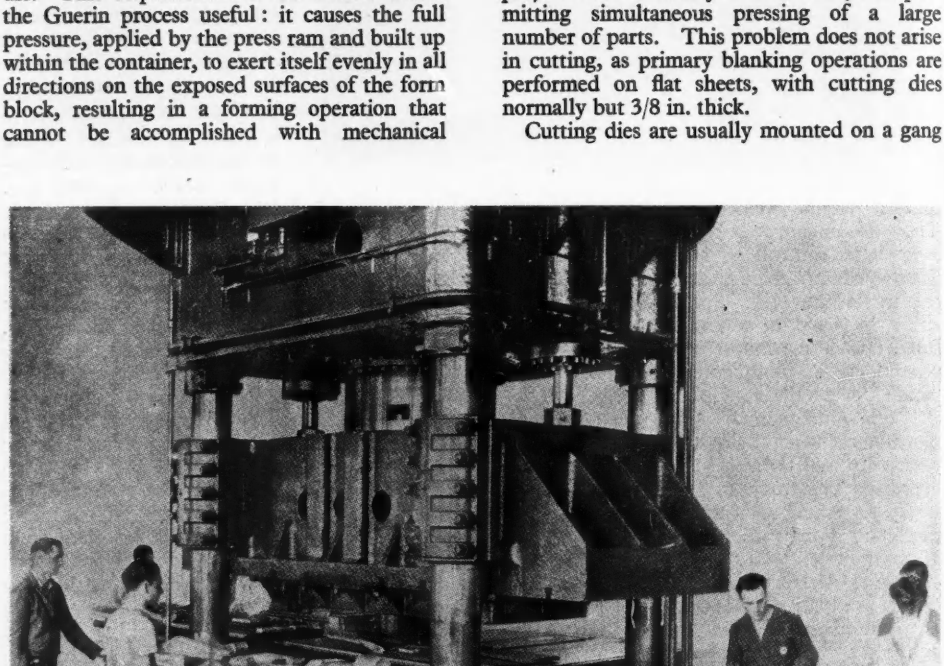
THE Guerin process employs a rubber pad that is fixed in a container attached to the moving platen or pressing ram of the press. This container, usually a casting, is approximately 1 in. deeper than the thickness of the rubber pad used, forming a recess, the sides of which extend down beyond the rubber. On the bed of the press is a pressing block, usually the approximate thickness of the rubber, corresponding with the recess in the container. As the container moves downward the pressing block enters the recess, and forms a semi-sealed chamber, in which the rubber is confined. The projection of the container, below the surface of the rubber pad as well as the thickness of the rubber, vary with the work for which the equipment is designed. The thickness of the rubber pad must be sufficient to

permit displacement of the rubber. The die must be permitted to push into the rubber pad without striking " bottom " on the container, within which the rubber is confined.

Rubber, being a plastic material and yet having the properties of a liquid in so far as compressibility is concerned, is displaced when meeting a solid object, such as a form block or die. This displacement of the rubber makes the Guerin process useful: it causes the full pressure, applied by the press ram and built up within the container, to exert itself evenly in all directions on the exposed surfaces of the form block, resulting in a forming operation that cannot be accomplished with mechanical devices which depend on punches and dies, and on a direct vertical or horizontal motion for the pressure.

For forming, the most practical adaptation of the Guerin method comes through grouping dies of comparable size on the pressing block, eliminating concentration of pressure on certain points in the container caused by the higher projection of unevenly selected dies, and permitting simultaneous pressing of a large number of parts. This problem does not arise in cutting, as primary blanking operations are performed on flat sheets, with cutting dies normally but 3/8 in. thick.

Cutting dies are usually mounted on a gang



The hydraulic press, well adapted for the Guerin process, is convenient for use with work-height loading tables.

cutting plate of sheet metal approximately 3/32 in. thick, which facilitates loading and scrap removal. The biggest advantage of the gang plate is its saving of material. Cutting blocks that are well arranged and nested on the gang plate leave a minimum of scrap. They can be placed closer together, and the arrangement given more careful study than when the blocks are placed at random or when the material is cut from individual rectangular-shaped pieces to be blanked to the shape of the part.

There is no particular problem in combining forming, forming and cutting, and straight cutting, all in a single press layout, which serves to illustrate the adaptability of this process to production work.

The use of loading tables to shuttle the tools and the material to and from the pressing block increases the efficiency and quantity of production from any type of press ; it also reduces hazard to the workman and decreases fatigue. Such installations are being employed in a number of foreign countries, as well as in the United States by licensees of the Guerin process.

Some of the Advantages of the Guerin Process.

Forming by the Guerin method does not shrink metal to any appreciable extent, and, if properly tooled, the operation will not stretch the metal materially during drawing operations. However, in forming simple flanges stretching does occur and is permitted within limits to simplify tooling. Likewise, in parts with simple flanges where a shrink is necessary, the practice of scalloping is allowed within established limits. For those parts on which scalloping is not permitted, the part is formed and the wrinkles are controlled by notching the form blocks.

In all cases the work should be tooled to effect a draw in the metal. This requires that the edges of the work be stabilized in such a manner as to permit the metal to slip and flow into the desired shape, as determined by the die. With the Guerin method it is possible to draw material into a dished shape, without shrink or stretch, by restraining the outer edge of the material under exactly the same pressure that is applied to the section being draw formed. This is the pressure of the restrained rubber which is, of course, identical in every part of the container within which the work is performed. As this pressure increases the material is forced into the shape of the die and the edge, being restrained by the pressure of the rubber, does not buckle but gradually slips or flows into the position determined by the die. Only when the restrained edge of the material has too much area exposed could sufficient friction be created to overcome the yield strength, causing it to stretch rather than flow. It has been found by experience that thin gauges of stainless steel handle much better with the Guerin method than by any other, except the most expensive methods employing conventional tooling. One-quarter hard stainless steel can be formed into some shapes. Aluminium, dural, mild steel, and soft stainless steel, form with good success when proper consideration is given to the specific forming problem and to tooling.

The limits for cutting operations in soft aluminium have been up to and including 0.051 in. The limits for forming operations in soft aluminium alloys are up to and including 3/16 in. in thickness. Combination cutting and forming soft aluminium alloys is accomplished with excellent success up to and including 0.040 in.

A recent addition to the scope of the Guerin method has been the hot forming of magnesium alloys. It is accomplished by the use of heater plates. It is desirable to form magnesium alloy parts at the lowest practicable temperature. The short time that the pad is in contact with the material, and the use of special composition, makes it practicable to use rubber with hot working.

Hydraulic presses have been found most satisfactory for application of the Guerin method. A standard hydraulic press with four strain rods is particularly well suited to loading the table equipment, permitting the use of four loading tables between the strain rods.

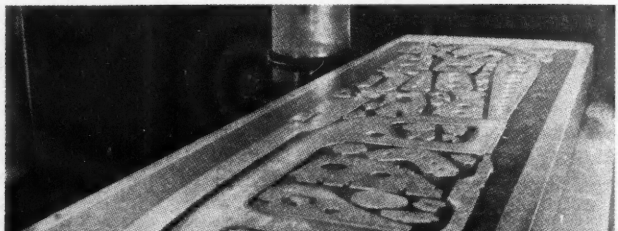
The simplicity of tooling under the Guerin method is outstanding in many ways. Form blocks are usually made from Masonite. The deep sections requiring more strength are made from cast materials such as zinc, Kirksite, Dowmetal, and aluminium alloys.

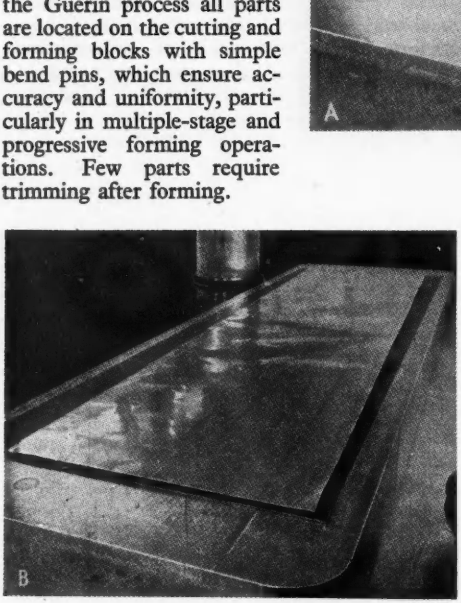
For practical reasons cutting dies are standardized. A Masonite block 3/8 in. thick is used in conjunction with a 1/32 of 1/16 in. chrome-molybdenum plate of proper shape to

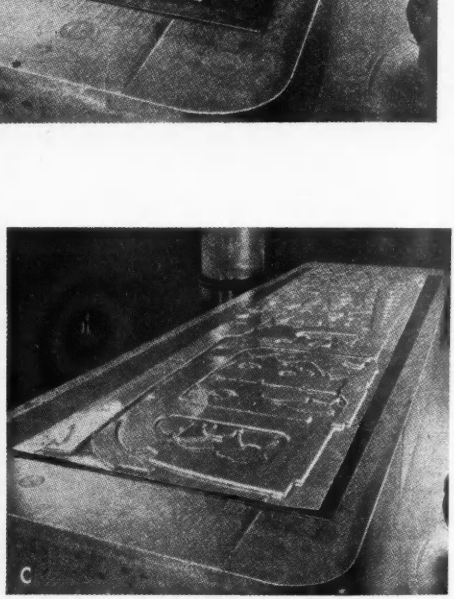
maintain the sharp edge at the point of cutting. These individual cutting blocks are then nested on the 3/32 in. steel gang plate.

Although piercing holes is not a major feature of the Guerin method, many parts are blanked, pierced and formed among the more than 5,000 different parts fabricated to date for the Douglas Aircraft Company.

For cutting or forming by the Guerin process all parts are located on the cutting and forming blocks with simple bend pins, which ensure accuracy and uniformity, particularly in multiple-stage and progressive forming operations. Few parts require trimming after forming.







Three steps in a gang cutting set-up illustrate: (A) nesting the cutting blocks to keep scrap to a minimum, (B) placing the aluminium alloy sheet over the blocks, ready for shearing, and (C) the clean work obtained, immediately after cutting.

"LANCIA-ARDEA," A NEW SMALL CAR

By DIPL. ING. MAX TROESCH. (From *Schweizerische Bauzeitung*, Vol. 116, No. 17, pp. 190-92.)

IN the motor-car industry a new design has been introduced by the Italian Lancia works. Fig. 1 shows this new type of small car, the Lancia-Ardea. Similar to other models manufactured by the same firm, the car is fitted with a "suspended" body, a four-cylinder V engine, and independent front wheel suspension. The V angle of the engine is very small, in order to reduce the heat losses (Figs. 2 and 3). The valves fitted in

the semi-circular cylinder head (compression ratio 6:1) are operated by a single camshaft situated above the cylinders. The design of the combustion chamber requires valves inclined to the vertical plane (Fig. 4). Since the axis of the rocking levers is not parallel to the camshaft a slight "scrubbing" movement exists between the levers and cams, but is of such small value that it can be disregarded. The lubrication of the rocking levers is very carefully designed and, in addition to the forced lubrication, small oil-wells on the top of the levers serve to lubricate the bearings if the motor is run too quickly when cold. The camshaft is supported by three bearings, and is directly driven from the crank-shaft by a double chain. The inlet and exhaust pipes to the motor are so arranged that the carburettor is fitted to one side of the motor, while the exhaust manifold is on the other side.

The cylinder block is a single casting, with a separate cylinder head, and is very short, due to the cylinder arrangement. The weight of the cylinder casting is greatly reduced since the sides do not extend down to the centre of the crank shaft, but instead—the sides of the aluminium crank case are brought higher up.

The forged aluminium connecting rods have a central channel passing through them for the lubrication of the gudgeon pin. The cooling water is circulated by a pump, and temperature regulation is obtained by a thermostat fitted between the cylinder head and the radiator. An adjustable metal shutter is also provided in the radiator grille for further temperature regulation.

A four-speed gear box, with silent second, third and fourth speeds, is flanged on to the motor. Although the gears are not "synchronised," changing of gears is very easy. The driving pinion is displaced with respect to the centre of the crown bevel gear in order to lower the cardan shaft.

The car is built up from three main parts: the floor-board (plate shaped), a front piece with the side panels and door and window-frames, and the back part with the roof. Each part is made of steel, and is electrically welded, forming a rigid construction.

Semi-eliptical springs with a rigid axle are used at the rear of the car. The front wheels are individually sprung with vertical cylinders and multiple coil springs. The closed spring casing encloses the hydraulic shock absorber, which is of a new design. The oil reservoir is fitted to the inside of the engine bonnet, and a valve fitted in the oil pipe controls the shock absorber when the car is running on rough roads. The arrangement of the front suspension is such that it allows the car to turn round in a street not more than 8.90 m. (29 ft.) wide.

The engine has a high thermal efficiency. The maximum output of the engine, with cylinders of 903 cm^3 capacity, at 4600 r.p.m., is 28.8 B. h.p. and 31.9 I. h.p. Considering the rigid construction of the engine this speed

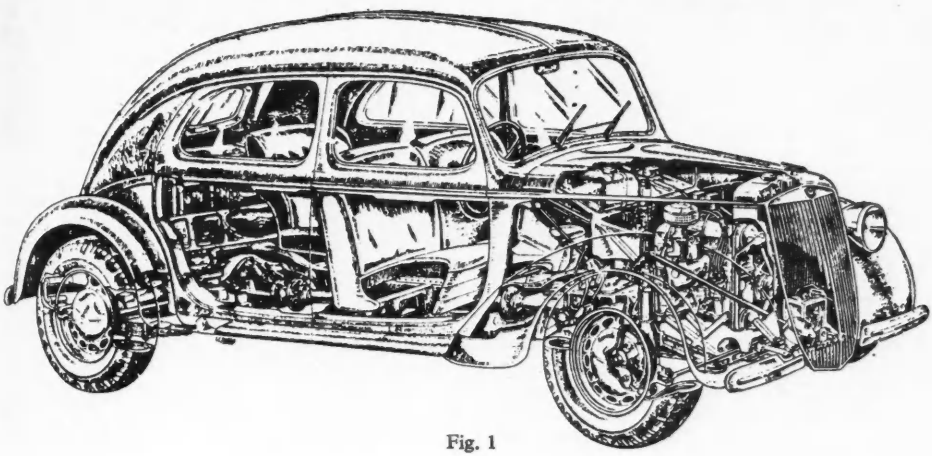


Fig. 1

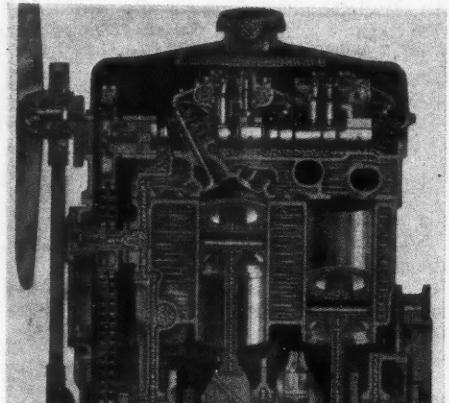


Fig. 2

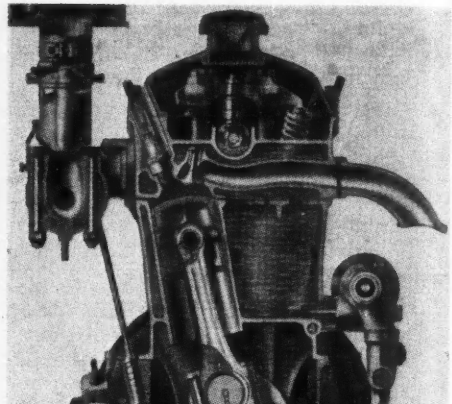


Fig. 3

cannot be considered high, and a vibrationless running of the engine is obtained. Fig. 5 shows the power output and fuel consumption speed curves of the engine. The minimum fuel consumption 227 gr/I. h.p. hr. is very good. The engine accelerates very well, and the car can run on top gear, even in close traffic.

The fuel consumption of the car was tested very carefully by the author. The car was tested with two passengers at 40, 50 and 60 km/hr. speeds, and the route on which it was tested included inclines, high road and town streets as well. The results are shown in Fig. 6. It should be mentioned that declutching, switching off the ignition, etc., was not made use of during these tests.

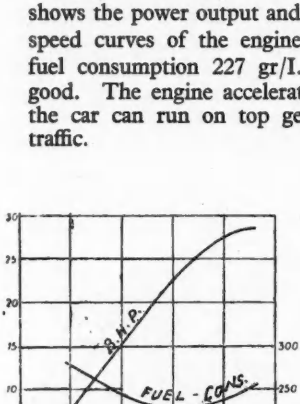


Fig. 5

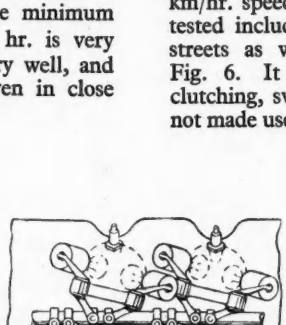


Fig. 4

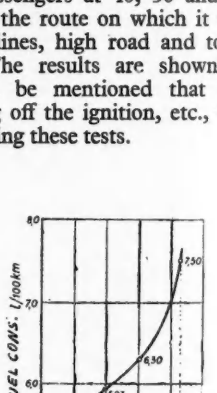


Fig. 6

THE METALLURGY OF MANGANESE

(From *Queensland Government Mining Journal*, Vol. 41, No. 15, October, 1940, p. 267.)

ELECTROLYTIC manganese from aqueous solutions has a long history leading up to its present commercial success in producing high-purity manganese at reasonable cost. In 1934 the Metallurgical Division of the Bureau of Mines undertook to find a practical solution of the problem. The electrolyte of manganous and ammonium salts recommended by Allmand and Campbell, and by the German workers, was accepted as satisfactory.

The first method developed utilised an electrolyte of manganese and ammonium sulphates in a diaphragm cell. A suspension of manganese carbonate was maintained in the anolyte as a means of controlling acidity. Sulphide ion was maintained in the catholyte in concentrations of about 0.1 gram per litre. The manganese produced was brittle. This was apparently the first time that a continuous deposition of high-purity manganese from aqueous solution had been maintained, even for 48 hours.

Several objections led to a revision of the process, the essential difference between this and the earlier process consisted in using manganese dioxide rather than manganese carbonate as the regenerating material.

The results of the studies by the Metallurgical Division of the Bureau of Mines were encouraging enough to justify commercial exploitation of the method. This has been undertaken by several companies in the U.S.A., and other countries abroad.

An important practical problem that must be solved, if the process is to be a success commercially, is elimination of sulphur found in the manganese produced by the Bureau's process. This may be accomplished by fire refining. Boric acid is an effective sulphur remover, and can be eliminated from the product.

It is, nevertheless, desirable to prevent the inclusion of sulphur in the deposit as far as possible. It was found that if the manganese were finely ground (-200 mesh) and introduced a little at a time, precipitation of cobalt, nickel and other metals could be accomplished with less than 1 gram of metal per litre. This is ideal, because no other impurity is introduced. It was also found that, with suitable variations, sulphide precipitations could be used, at least, as preliminary purification, for removal of most of the cobalt and nickel. Ammonium or barium sulphides can be used.

Oxidation of the manganese to the tricalent state, either in the tanks or during electrolysis, may be prevented by a number of re-agents as efficaciously as by sulphur dioxide. The important point is to have a re-agent that will not accummulate. A typical pilot-plant run at the plant of the Electro Manganese Corporation was as follows:

The catholyte was made up to contain 200 grams of ammonium sulphate and 35 grams of manganese, as manganese sulphate, per litre. The pH was adjusted slightly above neutral, and enough ammonium sulphide and activated charcoal added to precipitate nickel and cobalt. After standing two hours the solution was filtered. Catholyte was fed to each compartment at the rate of 10 c.c. per minute.

The anolyte, which had been used for precious tests, had a pH of 2.0 and contained, approximately, 4 grams of manganese per litre. It was fed at the rate of 740 c.c. per minute. Ten cathodes of 18-gauge steel were used. All plates were buffed and cleaned, except the one in frame nine, which had an oxide coating. This cathode was placed in the cell first, and a current of 100 amp. passed for five minutes. The plates were 8 in. wide, and were immersed 9 in., so the plating area was 1 sq. ft. Current density was 16 amp. per sq. ft. Voltage at the generator was 5, and at the cell 4.3. The pH of the spent electrolyte ran about 1.7. Manganese was plated for 20 hours. For eight of the ten frames the sulphur weighed from 0.21 to 0.40 per cent. Plating has been continued as long as 168 hours with better than 50 per cent. current efficiency, the plate thickness reaching $\frac{1}{8}$ in.

PRESSED MATERIAL BEARINGS WITH PRESSURE GREASE LUBRICATION FOR COLD ROLLING MILLS

By L. WEIS. (From *Metallwirtschaft*, Vol. 19, No. 6, 1940, pages 97-101).

ROLLING mill bearings should be designed to satisfy the requirements of the theory of lubrication, keeping in mind the necessity for withstanding high bearing pressures and heat generation. With the majority of rolling mill bearings, the journal speed is not sufficient to ensure admission of the oil and maintenance of the oil film, while clearances are also greater than in other bearings. The difficulty arising from the low journal speed can be overcome by admitting oil under pressure, and the larger clearances and greater heat generation can be counteracted by using a more viscous lubricant and proper cooling devices.

Experiments based on these principles were carried out with pressed material lining in gunmetal bushes on cold-rolling mills.

Preliminary investigations with drip feed lubrication and a water cooled bearing, at a bearing pressure of 120 kg./cm². showed an average coefficient of friction of 0.04, and breaking up of the oil film was experienced. With pressure grease lubrication, it was found that bearing pressures of the order of 240 to 290 kg./cm². could be used with a frictional coefficient of only 0.01. The journal speed was not recorded.

Further experiments were carried out on strip mills, with bearings of pressed material, the journal and bearing diameters being 260 m.m. and 400 m.m. respectively. It was found that the bush with the pressed material lining could be loaded up to the same bearing pressure as a gun metal bush. The strip mill has been working for the last year and a half, at 200 to 300 kg./cm² bearing pressure, without any appreciable wear.

A heavily loaded sheet mill, with journal and bearing diameters of 55 m.m. and 140 mm. respectively, and a peripherial journal speed of 51 m./s. is operating with a bearing lined with pressed material and using pressure grease lubrication, and although the bearing pressure is of the order of 250 to 300 kg./cm²., no troubles have been experienced in two years' service.

The limiting temperature at which pressed material bearings can be used at full capacity is about 100°C. Although metal bearings can withstand higher temperatures, up to 100°C the pressed material bearings proved equal or even superior to metal bearings.

FUEL SAVING IN CENTRAL HEATING INSTALLATIONS

By DR. O. STADLER. (From *Heizung und Lüftung*, No. 2, 1940, Report of the Swiss Material Research Station in Zürich).

As fuel saving became more urgent in war time, a great number of various apparatuses had been designed in order to improve the efficiency of the central heating plants. The efficiency of these apparatuses and their suitability were examined by the Swiss Material Research Station.

The saving apparatuses can be divided in four groups according to the principle on which they operate :

1. Improving the combustion.
   (a) Introduction of secondary air.
   (b) Using catalisator.
2. Chimney draught control.
3. Adjusting the heating surface of the boiler.
   (a) Increasing the heating surface.
   (b) Reducing the grate area.
4. Reducing the fuel consumption by indirect methods.
   (a) Screening of the ashes.
   (b) Removing the slag.
   (c) Checking the heat distribution.

Introduction of Secondary Air.

The design and installation of the apparatus is very simple. The apparatus consists principally of a cast iron body enclosing ducts to preheat the secondary air. These apparatuses were mostly used in connection with cast iron boilers and were fixed to the charging

doors. Sometimes the apparatus is fitted with pipes guiding the air to the spot where the secondary air is required. From tests it was found that the boiler efficiency could be increased by about 10% by the use of these apparatuses. It should be noted, however, that for the purpose of the test the joints between the cast iron sections of the boiler are usually refilled with putty, the boilers are cleaned, and the doors rendered air tight to prevent false air from entering into the boiler. These factors are partly responsible for the improved efficiency of the boiler, and should be allowed for, when considering the efficiency of the saving installation.

Using Catalisator.

Different kinds of saving powders have been brought to the market. These powders supply oxygen to the combustion and act as catalisators. Apart from the comparatively high costs, the efficiency of the saving powders is very small as the quantity of oxygen they give up is very small.

Chimney Draught Control.

This method may show good results where waste of fuel is due to excessive draught. The apparatus consists of a counterbalanced damper, adjusting the air inlet duct into the flue stack. The regulation of the apparatus is controlled by the chimney draught.

New types of draught stabilisers were designed to control the draught according to the flue gas temperatures and the draught.

The apparatus shows favourable results in installations which have a large draught. The installation of the apparatus must be carried out carefully otherwise it may lead to too small draughts, thus reducing the efficiency of the boiler instead of increasing it.

Increasing the Heating Surface.

Some of the boilers are designed to suit normal conditions, and on very cold days they are overrated. This causes an increase of fuel consumption which should be avoided. The installation of another boiler is sometimes impossible, and also a much cheaper remedy is given by enlarging the heating surface of the existing installation.

For this purpose water bottles are fitted into the boiler furnace. The bottles are connected to the water content of the boiler. This has two advantages: greater heating surface area, and improved water circulation due to the more intensive heating of the water.

Tests proved that in one case the capacity of the boiler was raised by 35% by enlarging the heating surface by 10%. 3% increase in the flue gas temperature was observed at the same time.

Reducing the Grate Area.

Since the outside design temperature for central heating plants is 20° C below zero, i.e., much lower than the average outside temperature, the heating plants are only partially rated during the greater part of the year, reducing the efficiency of the installation.

A part of the grate has been covered with fire bricks in order to save fuel. The bricks were of a special shape to fit into the standard type of cast iron boilers. Other covering plates have been made out of cast iron and were used to fill the vertical space between the grate bars. A reconstruction of the boiler by covering the grate area has been found most effective, and offers a considerable fuel saving.

Screening of the Ashes.

This indirect method of fuel saving is achieved by an ash container designed to prevent development of dust. A very large saving should not be expected, but may be economical in some cases considering the very low investment.

Removing the Slag.

Some tools have been designed to enable an easy removal of the slag, by knives fitted with hand levers. They might be quite useful for very large boiler plants.

Checking the Heat Distribution.

On the Continent heat consumption meters are used very often for central heating plants. The heat consumption of each individual flat is measured by an instrument placed in the radiators.

The heat meters are based on the principle to evaporate a liquid in a container on the radiator. The quantity of the evaporated liquid is a scale for the heat supplied by the radiator. Therefore, it is possible to charge the tenants the costs for heating according to the heat used in the respective premises. Thus, the tenants are prompted not to overheat the rooms, to shut the regulating valves when leaving the flat for a long period.

CORROSION OF AIRCRAFT METALS

(From *Technical News Bulletin of the National Bureau of Standards*, Washington, July, 1940, No. 279, p. 56).

APPROXIMATELY 25,000 specimens of aluminium alloys, magnesium alloys and stainless steels (60 alloys in all), have been corroded since 1925 at the Bureau, by means of accelerated laboratory tests or exposure to the weather or to sea-water. Corrosion was determined by means of loss in tensile properties, or was measured directly on cross section examined with the microscope at high magnification.

Corrosion in aluminium alloys occurred as either the " pitting " or intercrystalline types. Intercrystalline corrosion was responsible for serious embrittlement in duralumin-type alloys. Methods of heat treatment were evolved that eliminate intercrystalline attack. The work indicated that pitting could be minimized by preparing alloys from high-purity components, and by keeping the copper and iron contents low. Binary magnesium-aluminium alloys were found to become more susceptible to corrosion as the aluminium content increased. Small additions of zinc or tin rendered these alloys more resistant to attack. Stainless steels of the 18 chromium-8 nickel type, containing small additions of molybdenum, were more corrosion resistant than similar alloys without additional elements, or those with small additions of titanium or columbium.

Suitable surface coatings were developed, for both aluminium and magnesium alloys, to markedly improve their resistance to corrosion under severe saline conditions. The effect on corrosion produced by joining by means of rivets or by gas welds, seam welds, and spot welds was determined. Important data were also obtained on the potential effects involved when alloys of different chemical compositions were exposed in contact with each other.

AIR-BLAST CIRCUIT BREAKER WITH PARALLELING RESISTOR

(From the *Journal of Sprecher & Schuh S. A.*, Aarau, Switzerland, Vol. 1939, No. 3).

IN the Sprecher & Schuh air-blast breaker a resistor is inserted automatically in the circuit in parallel with a part of the arc just before interruption. It is claimed that this resistor gives great advantages to the breaker.

In Fig. 1 there is A the upper fixed contact, B a tube forming the movable contact, and C the lower fixed contact. In the closed breaker current flows from A over B to C. A is fixed in the converging port G of insulating material, which forms the entrance of the air into the chimney. The electrodes E and D are insulated. E is connected to one terminal of the resistor R, the other terminal of the resistor is in electrical communication with the movable contact B through the sliding contact F. The electrode D is in direct electric connection with the contact A. When the breaker opens, the contact B moves downwards, and, at the same time, compressed air is admitted through the port, as indicated in Fig. 1 by arrows, and makes the arc flow from B to D following the line II. Fresh air surrounding the arc insulates it from the contact A. A fraction of the current flows from the contact B through F and the resistor to contact E, and from there in the form of an arc (III) to the electrode D. Already before zero passage of the current, the arc B—E becomes unstable in consequence of the current flowing parallel through the resistor R and goes out. At this moment the de-ionisation of the path of the current from A to E begins. The current in R continues to flow until the moment of zero passage.

In the case of a short circuit with $\cos\sigma = 0$, the most severe condition for breaking a short circuit, the restriking voltage will follow the equation

$$\frac{du}{dt} \backsimeq 4\, f_0\, U\, \sqrt{2} \quad \text{Volt/sec.} \qquad (1)$$

where

f_0 natural frequency of the circuit in Hertz,

U effective voltage of the circuit in Volts.

This restriking voltage appears between A and

D on one side, and B and E on the other side. As mentioned before, A is already completely insulated by fresh air. But the distance B—E—D, still ionised by the arc just extinguished, is in danger of being bridged by a new arc. As long as there is no current flowing through R there is no voltage difference between B and E, and the voltage defined by equation (1) is working on the distance D—E. It is, therefore, this distance which will break down first. At this moment the voltage differences B—E and B—A will become equal to the voltage difference between the terminals of the resistor R

$$U_{RH} = R\,i\,.$$

This voltage follows the equation

$$\frac{du_R}{dt} = \frac{R}{L}\,U\sqrt{2}\,e - \frac{R}{L}\,t \quad \text{Volt/sec.} \quad (2)$$

as the voltage $U\sqrt{2}$ is inserted suddenly in the circuit with the inductance L and the resistance R.

Therefore a breaker without resistor must have a strong air blast in order to resist the rate of rise of voltage according to equation (1) and to avoid the restriking of the arc. As the voltage depends on the characteristics of the circuit (f_o), and as the breaker has to work even with the highest values of f_o, which may occur, a high pressure has to be used.

In a breaker with a resistor the recovery voltage is governed by equation (2), and is

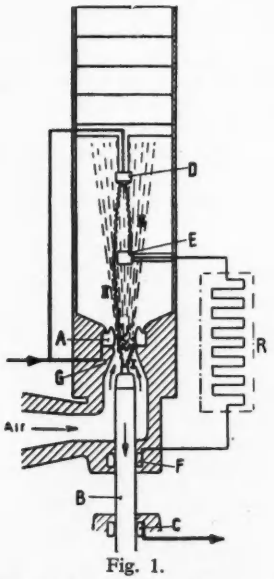


Fig. 1.
Sectional sketch of the chimney of an air-blast breaker.

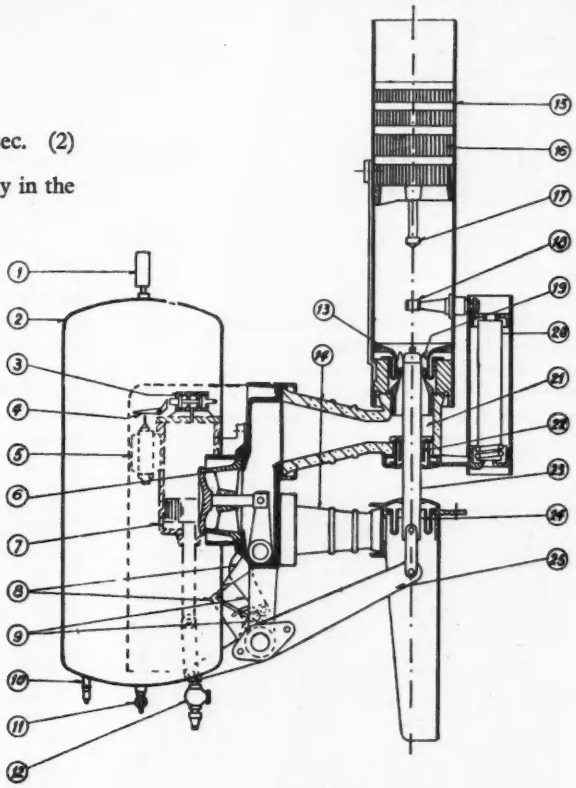


Fig. 2.
Sectional drawing of a low-pressure air blast breaker AF 100.

1 Manometer, 2 Air-reservoir, 3 Closing and opening valve, 4 Hand-release, 5 Closing and opening magnet, 6 Main valve, 7 Cylinder and piston, 8 Latch, 9 Operation of main valve, 10 Safety valve, 11 Venting valve, 12 Return valve and connection, 13 Nozzle, 14 Insulator, 15 Chimney, 16 Silencer, 17 Upper electrode, 18 Medium electrode, 19 Fixed contact, 20 Resistor, 21 Breaking chamber, 22 Auxiliary contact, 23 Contact pin, 24 Sliding contact, 25 Insulating lever.

independent of the natural frequency of the circuit. It is even possible to slow down the rate of rise of the recovery voltage by an appropriate value of the resistance. Consequently, a moderate pressure may be used in such breakers.

The current of the arc between D and E and in R is limited by the resistance R to the value U/R, and is, therefore, only a small fraction of the short circuit current. It is in phase with the voltage and is easily extinguished by the air blast, at zero point.

The resistor will not be cut in, when light currents are to be interrupted, as the air blast will interrupt the arc with the first zero passage. This is an advantage of breakers using low air pressure. Breakers with high air pressure may interrupt low currents before zero point, causing dangerous surges.

The following advantages are claimed for this type of breakers with automatically inserted resistor :

(1) Independence of the natural frequency

(2) Avoidance of surges

(3) Low pressure to be used for the compressed air, giving lower initial and working costs.

There is no extension of the time of interruption in consequence of the use of a lower pressure. The duration of the current flowing in R will not exceed 0.005 sec. Moreover, this current is so low that it cannot be regarded as a short circuit current.

The construction of the breaker may be seen in Fig. 2.

THE OERLIKON AUTOMATIC PLUG SWITCH, TYPE ST, FOR USE AS AUTOMATIC SWITCH IN L.T. INSTALLATIONS

By E. CHRISTELER. (From *Bulletin Oerlikon*, No. 225, 1940, March-June, pp. 1379-84).

THE new plug switch (Fig. 1) affords a complete solution of the problem to design a L.T. switch of high rupturing capacity, with dimensions such that it can be plugged in existing switchboards or distribution boards in the place of handle or tubular fuses. They are built for A.C. 500 volts for rated currents of 250 and 400 amps.

The advantages of these new switches are evident. In the case of temporary disturbances the plant can be put back in service without delay. Should the disturbance persist, the switch, which is equipped with trip-free release, trips immediately. In the case of frequent disturbances the saving achieved by avoiding the renewal of expensive silver

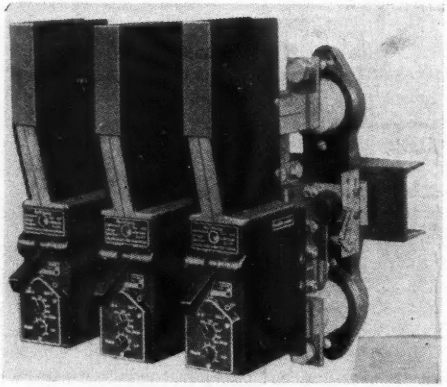


Fig. 1.
Oerlikon automatic plug switch, three single pole switches, with magnetic coupling.

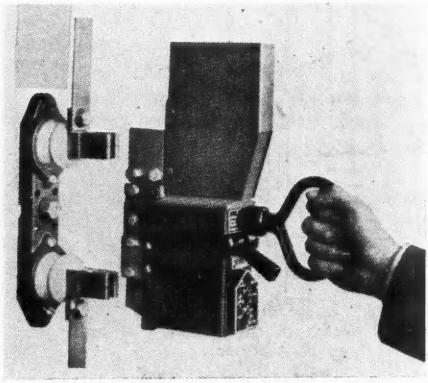


Fig. 2.
Insertion of an automatic plug switch by means of insulating handle.

fuses is considerable. The great accuracy and selectivity of the gear prevents sound parts of the system from being cut out. It is possible to link up two or three single pole plug switches with a coupling (Fig. 4), so that all poles are interrupted together. No separate lever switches are required for interruption of the circuit, as the plug can be plugged in or removed at will, the coupling of the plugs being automatically released and re-set.

In order to prevent accidental contact with live parts when plugging in or pulling out the plug switch, use is made of an insulating handle (Fig. 2), which is screwed into a tapped hole provided in the front of the switch. This can, however, only be done when the switch is in the off position.

The switches can be equipped with a definite time overcurrent relay with motor-driven timer, or with an inverse time overcurrent relay with thermal element. For both types instantaneous short-circuit release can be provided, which may be locked, if desired.

The plug switch type Stu with definite time overcurrent relay is particularly suited for densely interconnected networks, when an exact graduation of the release times of the switches is necessary in order to secure a selective isolation of the fault.

The plug switch type Sta with inverse time overcurrent relay has to be used where the main object is to utilise cables, transformers or other electrical apparatus up to the maximum permissible heating limit. For circuits feeding motors a mechanical coupling of the plug switches has to be provided (Fig. 3); the same applies if the plug switches are used as motor switches.

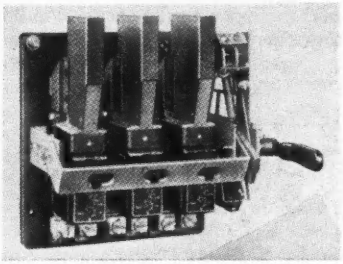


Fig. 3.
Three mechanically coupled automatic plug switches for direct operation.

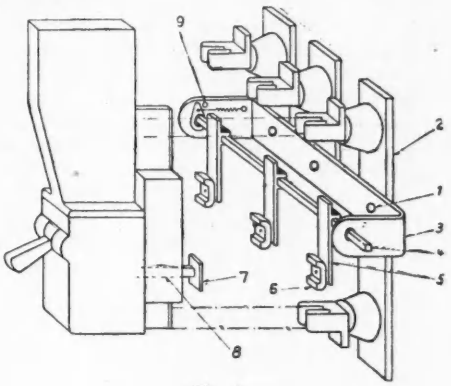


Fig. 4.
Magnetic coupling gear of the releases.

The plug switches are of single pole design. However, as mentioned before, two or three can be coupled together in such a way that, although the switches are still closed independently, they can be opened together by hand or automatically. The coupling of the release device is shown in Fig. 4. The connecting device consists of an adjustable bearing bracket 3, a connecting spindle 4, and adjustable levers 5, carrying permanent magnets with free play 6. This coupling gear transmits the opening motion of the switch, which is released, to the tripping devices of the two other switches. At the same time as the release mechanism shifts the coupling gear away from the stop 9, the permanent magnets 6 draw the armatures 7 of the two other automatic switches, and cause their release. The coupling gear is adjustable for various distances of poles, and can be adapted to the lower part of fuse supports of new or existing installations. Owing to the use of permanent magnets the coupling gear is released, when the switches are drawn out and connected up, when the latter are plugged in, without any further measure.

The permissible rupturing current for both types is 10.000 amps (effective value) at 500 volts A.C. and $\cos\sigma = 0.1$, and with non-locked instantaneous release. When the instantaneous release is locked the rupturing capacity of switches for rated currents below

200 amps is reduced by reason of the necessity of keeping the current in the relay winding within a certain limit, in regard to heating. The short-circuit release will, however, only be locked when, for service reasons, the task of interrupting a short-circuit must be taken over by another switch in the system.

The dimensions of the switch are given by Fig. 5. Dimension A may be 160-170 mm. or 200-210 mm.

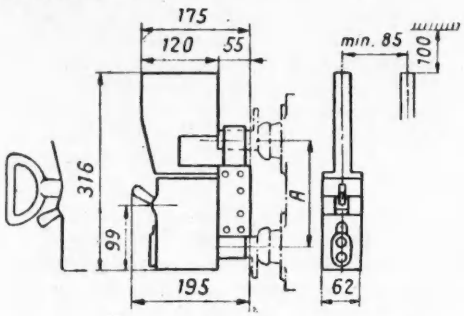


Fig. 5.

Dimension of types Stu and Sta in mm.

The principle technical data for the relays are as follows :

(a) Type Stu with definite overcurrent release : Accuracy of current working : ± 8% to 10% of setting ; Functioning time : 0.2 to 4 sec. at 50 cycles, with an accuracy of ± 0.05 sec.

Size	Rated Current	Actuating Curr. adjustable between	Max. permissible sustained Current
Stu-250	66 amps.	60-120 amps.	100 amps.
„	133 „	120-260 „	200 „
„	200 „	180-400 „	300 „
Stu-400	400 „	360-800 „	500 „

Instantaneous relay adjustable for values of current from three to seven times the rated current of relay.

(b) Type Sta with inverse time overcurrent thermal release : Accuracy of current working : ± 10% of setting ;

Size	Rated Current of relay	Full Load Currents adjustable between
Sta-250	133 amps.	83-165 amps.
„	200 „	125-250 „
Sta-400	200 „	125-250 „
„	400 „	250-500 „

Instantaneous release as for type Stu.

The inverse time overcurrent relay is absolutely immune to short-circuits.

UNIPOLAR GENERATOR FOR LOW VOLTAGES AND HIGH CURRENTS

By M. ZORN. (From "*E.T.Z.*," *Elektrotechnische Zeitschrift*, Vol. 61, April, 1940, pp. 358-360, continued from THE ENGINEERS' DIGEST, Vol. 1, No. 7, December, 1940, p. 262).

(4) Efficiency in comparison with Copper Oxide Rectifiers.

The losses through friction of the brushes are :

$$V_b = 9.81 \frac{2\,I}{i} v_b \mu p \text{ Watt};$$

the contact resistance losses are :

$$V_r = 2\,u\,I \text{ Watt},$$

where :

I=current.

i=current density under the brushes.

$\frac{2\,I}{i}$=contact surface of the brushes.

v_b=velocity of the rotor under the brushes.

μ=coefficient of friction.

p=specific pressure of the brushes,

u=voltage drop in the brushes.

Assuming i=25 A/cm.², v_b=33m./sec., μ=0.15, p=0.18 kg./cm.², u=0.25 Volt, then

$$V_b = 0.7\,I,\ V_r = 0.5\,I.$$

The losses by air resistance, bearing friction, and the losses in the exciter winding may amount to about 0.2 I. Hence, the total losses are :

$$V = 1.4\,I \text{ Watt.}$$

The efficiency of the machine is :

$$\eta = \frac{U\,I}{U\,I + V} = \frac{U}{U + 1.4}$$

Besides the losses in the unipolar machine, the losses in the motor driving the machine have to be taken into consideration. Assuming for an induction motor, an average efficiency of 93%, a better full load efficiency is obtained for the unipolar machine than for a Copper-Oxide Rectifier for voltages higher than 6 volt. The difference in favour of the unipolar machine

becomes the greater the higher the voltage of the machine (Table I).

(5) Reliability of the unipolar machine and future developments.

The new type of unipolar machine is very reliable. Nevertheless it would be of interest to find a better solution for collecting the current than to collect it by brushes. It may be advantageous to use mercury. Although applications for patents covering this principal have been made, no realisation of the idea has been achieved up to to-day. The losses could be reduced to a fifth. In order to avoid oxidation of the mercury the machine would have to run in a nitrogen atmosphere.

TABLE I.

Efficiency of Unipolar machines.

Load	50%	100%	150%
Unipolar machines, 20 V.	89%	94.3%	94.5%
„ „ 10 V.	81%	88%	90%
„ „ 5 V.	69%	78%	82%
Unipolar machines driven by induction motor, 20 V.	82%	86.5%	87%
Ditto., 5 V.	62.6%	72.5%	76.3%
Copper-Oxide Rectifier..	76.5%	74%	70%

STUDY OF THE REFRACTORY PROPERTIES OF TOPAZ

(From *American Ceramic Society*, Vol. 23, No. 9, September, 1940, page 265-270.)

Introduction.

TOPAZ possesses properties and a chemical composition which are unique. The chemical formula is $/Al(F,OH)/_2SiO_4$ or $/Al(F,OH)_2/AlSiO_4$. Fluorine and hydroxyl water are isomorphus and are variable in relation to each other. Apparently Topaz furnishes its own mineralizer, raises itself in refractory value through heating, and changes in chemical and mineral composition during heating toward a compound having high stability against glass or silicate slag. It has a hardness number of 7 in Mohs' scale.

Refractory Properties of Topaz.

Topaz has possibilities as an excellent refractory raw material for the following reasons :

1. It is an aluminosilicate, high in alumina combined with two volatile substances, fluorine and water. Firing during the manufacturing process will drive off the volatiles and leave a nearly pure aluminosilicate, which may be expected to come to equilibrium indicated by the equilibrium diagram for the system: Al_2O_3-SiO_2.
2. High purity and freedom of fluxing alkalis, or other metallic elements.
3. The fluorine and water content are potent catalisers for the formation of stable mullite. They will remove part of the silica by volatilization.
4. It has exceedingly small grain size. The interlocking intergrowth of the grains makes for a strongly knitted, finished product.

Description of Deposit.

The deposit in South Carolina, pure and large enough to be a potential source of raw material for the manufacture of refractories, is known as the Brewer deposit. The country rock is a quartz-sericite schist, in which the topaz occurs in a vein or veinlike body.

Although exact quantities of ore have not been blocked out, all indications point toward a large Topaz deposit in the ground and adequate reserves for use for a number of years in the refractory industry. In addition to the vein material, there is a large quantity of placer topaz in boulders up to 12 in. in size. Most of the topaz found in this area is gray or mottled and streaked in shades of gray. It shows a conchoidal fracture with a waxy lustre.

Change of Optical Properties and Mineral Transformation by Heat.

The firing behaviour of the Brewer Topaz was determined with placer-mine lumps, selected for uniformity, and calcined for 5 hours at 1000, 1500, 2000, 2500, 2700, 2800, 2900, and 3000 F. The mineral transformations were followed by studying powder and thin sections under a petrographic microscope (Fig. 1).

The topaz occurs as a mosaic of intergrown and interlocking subrounded grains from about 0.0015 to 0.005 mm. diam. and in occasional short stringers that may contain grains of sizes up to 0.15 mm. at their centres. More than 90% of the material, however, occurs in fine-

grained intergrown, granular form, which is likewise characteristic of chert. The main index of refraction of topaz is about 1.63.

Pyrite, energite, and gold in small quantities was found in the mines, but none of these minerals was found in the material mined for refractory use.

The fine grains of topaz showed little change until it was calcined at 1500 F, at which temperature slight cloudiness appeared and the principal index of refraction decreased to 1.622. The crystalline lattice remains intact in some of the material, but often sufficient disruption has occurred to give undulatory extinction (Fig. 2).

In the calcination at 2000 F, maximum disruption of the optical lattice occurred as shown by the low index of refraction, 1.607. New cracks, opened during the heat treatment, traverse the lumps, but are rarely persistent or deep enough to split them. Three different types of materials are distinguishable in the thin sections (Fig. 3). One of these is topaz, only slightly altered. Another is the coarse grains of topaz almost inverted to fairly coarse needles of mullite, averaging about 0.06 to 0.01 mm. in size. The third type of material is the predominating, originally fine grained and transparent groundmass aggregate. This is now clouded to a tan or light brown color, what appears to be a fine dust. Any silica that might be released during the inversion to mullite, will set up refraction boundaries and surfaces. The wide difference between the mean indices of mullite 1.640, topaz 1.630, and silica 1.462 indicate the extent to which the dark borders can develop. The cloudiness is largely dispelled at higher temperatures.

At 2500 F (Fig. 4) mullite development is prominent. Chemical and physical tests confirm the belief that mullite inversion is essentially complete below 2500 F. The water-clear, lustrous silica glass has coated more parts of the surface than at the lower temperatures. The silica glass coating was identified by its index of refraction.

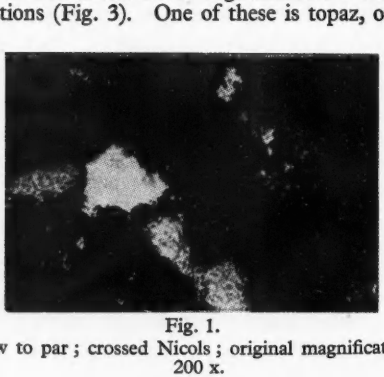


Fig. 1.
Raw to par ; crossed Nicols ; original magnification 200 x.

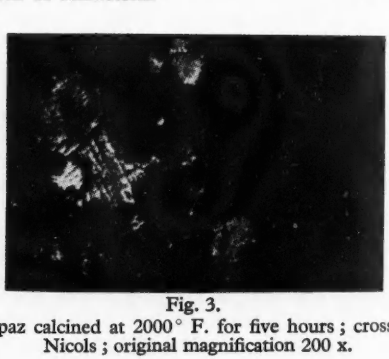


Fig. 3.
Topaz calcined at 2000° F. for five hours ; crossed Nicols ; original magnification 200 x.

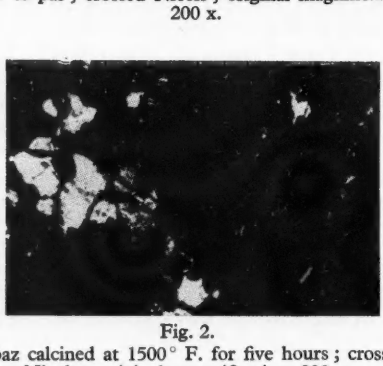


Fig. 2.
Topaz calcined at 1500° F. for five hours ; crossed Nicols ; original magnification 200 x.

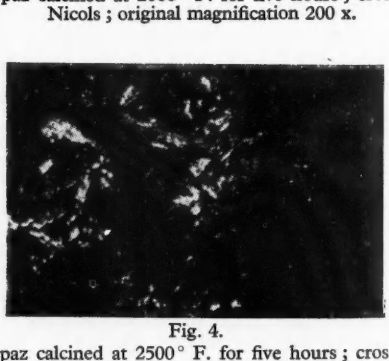


Fig. 4.
Topaz calcined at 2500° F. for five hours ; crossed Nicols ; original magnification 200 x.

Topaz heated to 2700 and 2800 F (Fig. 5), shows progressively larger mullite needles. The cloudiness of the groundmass begins to disappear at 2700 F.

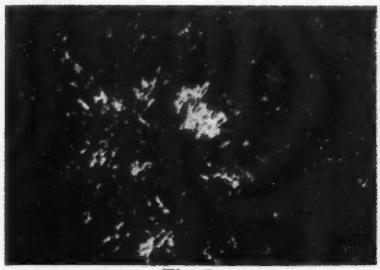


Fig. 5.
Topaz calcined at 2800° F. for five hours; crossed Nicols; original magnification 200 x.

At 2900 and 3000 F, topaz seems to be at equilibrium as far as mineral development is concerned. A more homogenous network of interlocking crystals has developed. The mullite crystals are nearly transparent in the thin sections.

Change in Physical Properties by Heat.

Important changes were taking place in the temperature range 2000 to 2500 F. Additional lumps of raw topaz were calcined for five hours at 2200 and 2300 F, and the test determinations were made on these samples. Fig. 6 is the chart of the results showing 2300 F to be the critical temperature for a calcination time of five hours. It is not yet known whether this same result could be achieved by longer calcination at lower temperatures.

Change in Chemical Composition by Heat.

A chemical analysis of raw topaz given by Pardee is as follows:
Si 0_2 33.00, $Al_2 0_3$ 50.70, $Fe_2 0_3$ trace, $H_2 0$ 0.04, $H_2 0$ + 2.67, and F 13.23%
a total of 105.70%, minus O=F= 5.57, a total of 100.13%.

When this material is calcined at temperatures of 2500 F and above, the volatiles, fluorine and water, are driven off and carry with them a certain amount of silica.

Analysis made by a commercial testing laboratory show the raw topaz to have 30% of silica, 53% of alumina, and other portions of the same sample which had been calcined at a

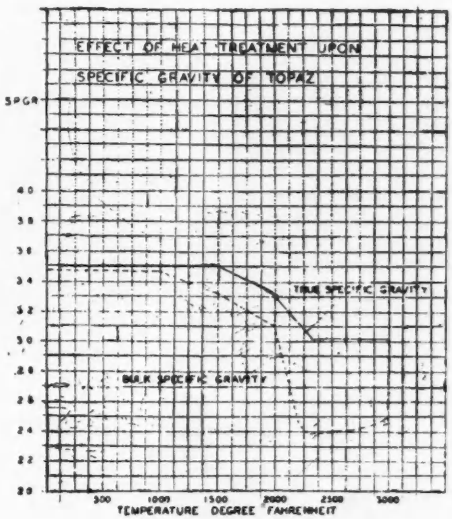


Fig. 6.

temperature of 2500 F show 31% silica and 61% alumina. As the removal of the fluorine and water only would have raised the silica content to 36%, it is evident that 5% of silica was removed with the volatiles. This is verified by chemical analysis of the nearly transparent scale which covered the surface of the calcined lumps. The scale was found to have 92% silica.

Properties of Brick Manufactured from Raw and Calcined Topaz.

A number of standard size bricks were made from both raw and calcined topaz by the normal dry-press process, using 15% of a 28-mesh refractory bond clay in both cases.

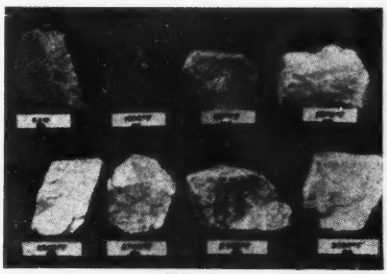


Fig. 7.
Changes in appearance of topaz with heat treatment.

The brick made from the raw topaz was fired in a tunnel kiln to approximately 2700 F. For the calcined topaz brick, the topaz was precalcined to about 2700 F. and fired in a tunnel kiln to 2500 F. The fired brick resulting from these two mixes presented quite a contrast in appearance. The raw topaz brick was covered with scale and blisters resulting from the elimination of silica during firing. The brick made from the precalcined topaz on the contrary showed a pleasing appearance, creamy white, and with a few surface imperfections.

The result of the standard A.S.T.M. test made on both types of bricks is given in the following table:

TABLE.

Physical test on 9 in. topaz bricks.

P.C.E., A.S.T.M. C 24-35.	Dry-pressed from raw topaz, cone 38	Dry-pressed from precalcined topaz, cone 38
Temperature equivalent (Bur. St. scale) ..	3335 (1835 C)	3335 (1835 C)
Reheat (permanent linear change) test, 5 hours at 2912 F, contraction % ..	0.87	0.47
Hot load test, superduty (2642 F, 1½ hours, 25 lb.) compression % ..	0.25	1.56
Panel spalling test (3000 F), loss %	34.7	no loss
Apparent porosity (%)	24.2	26.6
Modulus of rapture, lbs/sq. in.	3810	1190

AN EXPERIMENTAL DETERMINATION OF THE LIFT OF AN OSCILLATING AIRFOIL

By ELLIOTT G. REID and WALTER VINCENTI. (From *Journal of the Aeronautical Sciences*, Vol. 8, No. 1, pp. 1-6, Nov., 1940).

EXTENSIVE theoretical studies of the non-uniform motion of airfoils have been made to aid in the undertaking and solution of the problems of wing flutter, gust loadings, flapping-wing flight and accelerated flight in general. The subject of the present report is an experimental investigation of the validity of this phase of the theory.

The accepted theory of non-uniform airfoil motion is based upon the following concepts: Oscillatory motion introduces two effects which are absent in uniform motion. One arises from the non-uniform acceleration of the fluid in the direction normal to that of the translatory motion. The other originates in the velocities induced at the position of the airfoil by the wake of transverse vortices discharged as a result of the variation of lift.

The simplifying assumptions utilized in developing the theory are:

(1) The motion takes place in the ideal fluid.

(2) The strength of the circulation around the airfoil is such as to preclude flow around the trailing edge at all times.

(3) The airfoil may be replaced by a flat plate.

(4) The amplitude of oscillation is small.

(5) The vortices of the wake remain fixed with respect to the undisturbed fluid.

The lift characteristics predicted by the theory for the case of sinusoidal pitching oscillation are:

(a) The lift will vary sinusoidally.

(b) The variation of lift may be either greater or less than that which would occur if the oscillation were infinitely slow, i.e., if at each angle of attack the lift were that corresponding to steady motion.

(c) The variation of lift may either lead or lag that of the angle of attack.

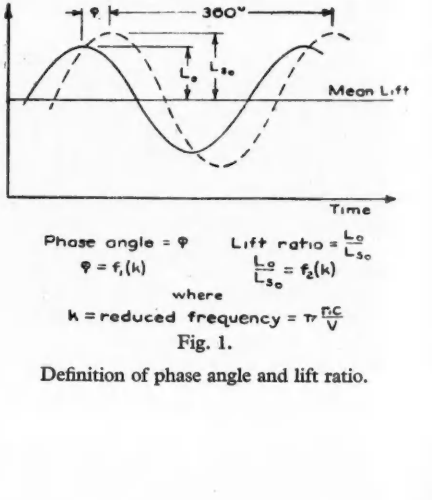


Fig. 1.

Definition of phase angle and lift ratio.

(d) The phase angle and amplitude of the variation of lift will depend upon the location of the axis of oscillation and upon a non-dimensional parameter known as the "reduced frequency."

The predictions are diagrammatically illustrated in Fig. 1. The broken-line sine curve defines the variation of lift which would occur if at each angle of attack the lift were that corresponding to steady motion. The solid-line sine curve represents the actual variation of lift which occurs during a particular sinusoidal oscillation. When the axis of oscillation is fixed, the theory defines the phase angle Φ, and the lift ratio L_o/L_{so} as functions of the "reduced frequency," k.

The physical significance of the reduced frequency becomes apparent when one examines the definitive equation:

$$k\,2.\ \frac{n\,.\,b}{V}\ \frac{.n.c}{V}\ \frac{.n}{V/c}$$

in which is the absolute frequency of oscillation (cycles/sec). b is the half chord length, c is the chord length, and V is the velocity of translations (ft/sec).

It is important to note that the theoretical lift ratio and phase angle are independent of the amplitude of oscillation and mean attitude of the airfoil so long as the linear range of the list vs. angle of attack curve for the steady state is not exceeded during oscillation.

Although measurements of the lift and moment under numerous conditions of oscillation would be required for complete verification of the theory of non-uniform motion, it was believed that a study of one of these quantities under a single condition should yield valuable indications of the validity of the basic concepts and simplifying assumptions. An investigation of the lift of an airfoil which performs sinusoidal pitching oscillations about a spanwise axis, was selected for this purpose.

The experiments were carried out in the wind tunnel of the Guggenheim Aeronautical Laboratory at Stenford. The model a 15 by 36 in. N.A.C.A. 0015 airfoil which consisted of a steel tube spar, five dural ribs, and a one-piece sheet aluminium skin, was installed between vertical partitions as shown in Fig. 2. The right-hand end of the airfoil spar was supported by a special force recording dynamometer, which was entirely enclosed within the

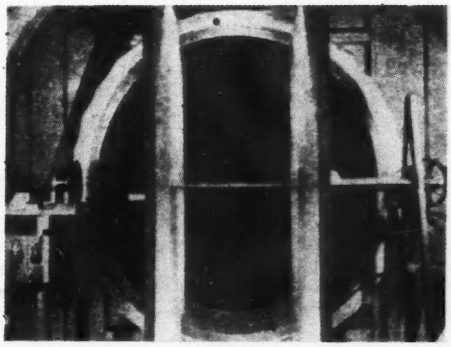


Fig. 2.
General view of apparatus (as viewed from downstream.)

left-hand partition. Details of the driving mechanism may be seen in Fig. 3. The geometry of this mechanism was such that the actual angular velocity deviated from that for simple harmonic oscillation by less than 0.25% when the amplitude was approx. 5%.

The recording dynamometer is shown in Fig. 4. The dynamometer consisted of a short horizontal cantilever spring A, which was anchored to the channel and in turn supported the free end of the airfoil spar on a self aligning ball bearing located in the block B.

The application of a lift force to the airfoil produced a minute deflection of the spring, correspondingly larger deflection of the extension arm C and stylus D, and a considerable angular deflection of the pivoted mirror E. This caused the reflected light beam F G I K to sweep along the slit of the motor driven recording camera K. A stylus of adjustable eccentricity was provided at O for variation of

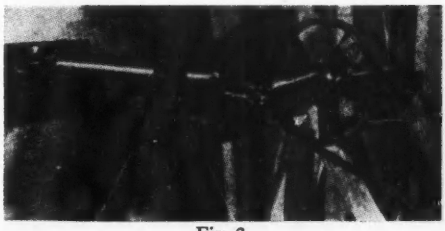


Fig. 3.
Driving mechanism (streamlined housing removed).

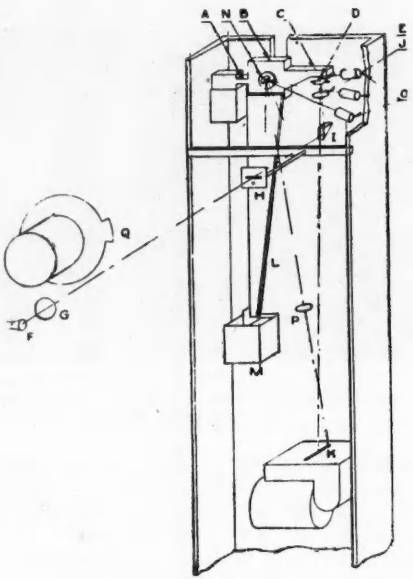


Fig. 4.
Diagram of recording dynamometer.

the magnification, and damping was accomplished by use of the arm L and the vane and dash-pot M.

The passage of the airfoil through its mean and extreme position was recorded by the sweeping of three light beams back and forth across the slit of the camera. These beams originating in the approx. adjusted "lighthouse" O, were reflected by a small mirror at N which rotated with the airfoil.

The natural frequencies of the dynamometer with model in place were found to be 78 and 115 cycles per second, for the light and heavy spring respectively. At an oscillating frequency of 8.82 cycles per second, the highest used in the test, the lag of the recorded deflection with respect to the impressed force was found by analysis to be consequently 0.45° lower even when the lighter spring was used. The steady state lift curve of the airfoil was established by recording the lift at a dynamic pressure of 6.9 lb./sq. ft., with the airfoil set at angles of attack ranging from 2° to 17°. The experiments completed included nine oscillation tests made at an absolute frequency of 4.25 cycles per second and one at an absolute frequency of 8.82 cycles per second. The records of the oscillating lift were marked by the presence of a secondary fluctuation of relative frequency. This fluctuation was evidently the result of a self-induced vibration of the airfoil or recording mechanism, but efforts to discover the source of energy input or to damp out the vibrations were unsuccessful. As a result it was impossible to obtain the desired data by measurement directly from the record.

It was possible, however, to separate out the variation in lift with good accuracy by means of a numerical harmonic analysis; the amplitude of the fundamental harmonic of the curve and its phase shift relative to the mean position dots were determined. The lift ratio was then obtained by proper comparison of the resulting amplitude, with the deflection of the light beam in the steady lift record.

The phase angle was provided directly by the phase shift computed from the harmonic analysis.

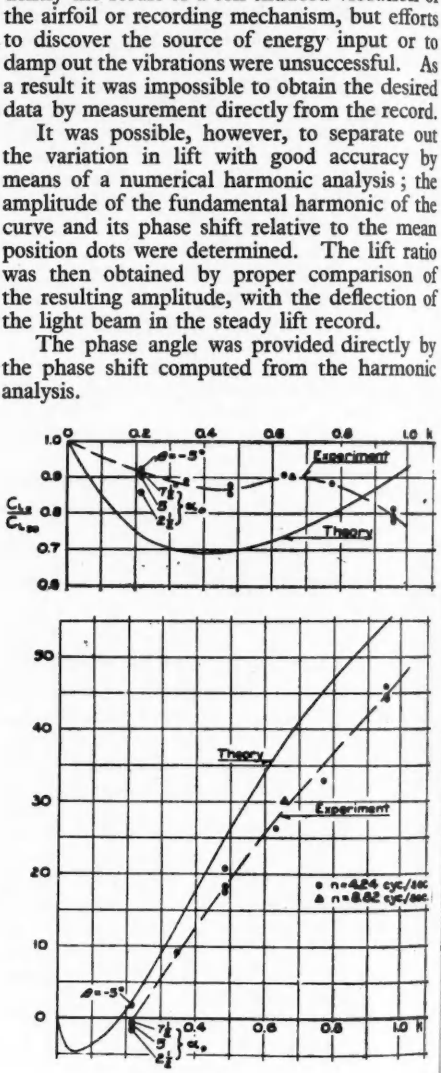


Fig. 5.

The latter steps in the analysis were complicated by certain small corrections which were necessary to compensate for inadvertent misadjustments of the recording apparatus. The corrections did not affect the mutual consistency of the data. They did, however, slightly decrease the disagreement between the experimental data and the theoretical predictions. The final results of the tests are shown by the circled points in Fig. 5, where the lift ratio C_L/C_{Lso} and the phase angle of the oscillating lift are plotted against the reduced frequency K. The theoretically predicted results are also included in Fig. 5. It can be seen that throughout the range investigated, the experimental phase angles vary with the reduced frequency in general manner predicted by theory. The experimental values are, however, consistently smaller than the theoretical ones. For reduced frequencies less than about 0.7, the lift ratios are in qualitative agreement with the theory, but are larger than predicted. For reduced frequencies from 0.7 to 0.95, the experimental lift ratios do not agree with the theoretical results in either magnitude or sense of variation.

No satisfactory explanation for the discrepancies between the theoretical and experimental results is known to the authors.

Examination of the possible sources of experimental error indicates that the variation in results between different cycles of the same test is the only one of any consequence. But these are not of the order to account for the discrepancies noted.

The most apparent difference between experimental and theoretical conditions is that the airstream did not extend to infinity above and below the airfoil. It is known that such boundaries have a considerable influence upon the lift of a stationary airfoil. In the present tests, it was found that application of theoretical connections for this influence resulted in a complete correlation between the relatively low measured slope of the conventional steady state lift curve and the infinitely aspect ratio values deduced by other investigators. What effect the finite stream has upon the lift of an oscillating airfoil is not known at present.

A second shortcoming of the experimental installation was the possible deviation between the tips of airfoils and the vertical partitions. This effect is undoubtedly small.

A third shortcoming, the use of airfoil of moderated thickness, instead of a flat plate, is thought to be of no consequence.

Among the assumptions of the theory, one, which is not fulfilled, is that of the perfect fluid. It is probable that the boundary layer in the oscillating case, is, itself, oscillatory in character, and that its action may, therefore, be considerably different from that of the boundary layer in steady flow.

The second assumption of theory, that there is no flow around the trailing edge of the airfoil at any time, is certainly open to question. It is known, for example, that a change in the attitude or motion of an airfoil is accompanied by flow around the trailing edge for a short time, following the change. Since oscillating motion may be thought of as a continuous series of such changes, it might be supposed that flow around the trailing edge does actually take place during the major part of each oscillation.

It may be said that the results of this study agree qualitatively, but not quantitatively with the predictions of theory of oscillating airfoils for reduced frequencies less than 0.7. For reduced frequencies from 0.7 to 0.95, the phase angles of the oscillating lift ratios, however, vary in the sense opposite to that predicted.

It is interesting to note that this latter disagreement occurs in part of the range of reduced frequencies from 0.69 to 1.14, within which airplane wing flutter was observed in actual cases. This would appear to cast some doubt upon the applicability of existing theory to the practical problems of wing flutter.

RECIPROCATING STEAM ENGINES FOR INDUSTRIAL HEATING INSTALLATIONS

By E. HABLUTZEL. (From *Schweizerische Bauzeitung*, Vol. 116, No. 14, October, 1940, p. 159).

THE thermal economy of heating plants can be considerably improved if the steam in the heating system is previously used to drive a heat engine. This consideration induced the SLM-Winterthur works to construct a vertical uniflow-steam-engine which can be fed with fresh steam up to 20 a.t.m. pressure as well as with exhaust steam at a wide pressure range. In a particular installation, the boiler pressure varies between 0.5 and 1.5 a.t.m. The steam is super-heated to about 300-320° C., and the engine is running at 500 r.p.m. The pressure of the exhaust steam can be adjusted on an auxiliary steam outlet. The latter also enables the engine to run on exhaust steam, as a single expansion engine. The exhaust valve throttles the steam in the exhaust port, through which steam can be carried away. The engine is shown in Fig. 1.

A uniflow-steam engine was also constructed for a Macadam producing installation. Formerly, fresh steam was employed to heat the mixture, while an I.C. engine provided the drive to the mixing drum and other machinery. In the new design, the steam engine takes the place of the I.C. engine, and the exhaust steam is used to heat the mixture. The operation of the plant is very satisfactory.

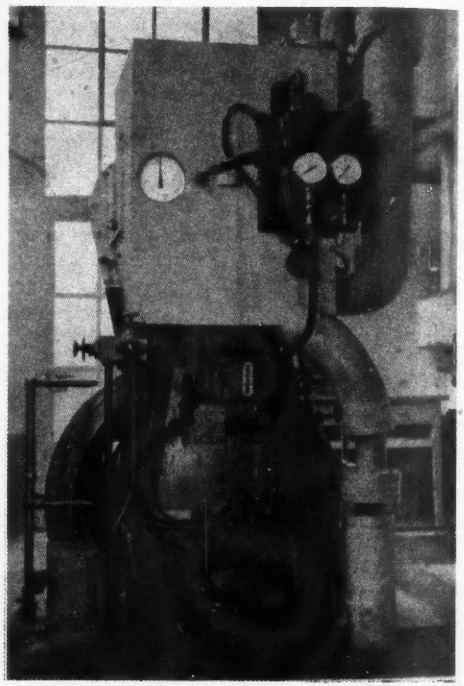


Fig. 1.

THE PHYSICAL PRINCIPLES FOR THE CONSTRUCTION OF DIESEL ENGINES USING LIQUIFIED GAS AND DIESEL OIL FUELS

By DR. ING. F. NEUGBAUER and DR. ING. E. WACHSMUTH. (From "*MTZ*" *Motortechnische Zeitschrift*, Vol. 2, No. 3, March, 1940, pp. 76-79).

LIQUID gas fuels differ mainly from the usually employed oil fuels in that they are more volatile and ignite more readily. It would be desirable to construct a Diesel engine which could work with both these fuels. The idea to inject the gases in a liquid state directly into the combustion chamber is not new, but it is also known that an injection pump cannot solve the problem, since the liquified gas evaporates during the suction stroke, and hence, the pumping process would be disturbed. If the pump is supplied with the liquified gas fuel under a higher pressure than the vapour pressure of the fuel at the particular temperature existing in the inlet chamber, the pump still ceases to operate after a few pumping strokes. Similarly, the result was unsatisfactory if the pump was supplied by an intermediate pump, since in this case the latter suffered from the disadvantage mentioned before.

From the results it was found that apart from the great volatility of the fuel, gases (air) are also absorbed in large quantities and are liberated at a point where the pressure is not so high. The first improvement was obtained by passing the fuel to a vapour separator by means of an intermediate pump (Fig. 1). The vapour is continuously conveyed back to the main tank, and hence, does not disturb the action of the pump. The suction tube is deeply immersed in the tank to ensure a gas-free fuel intake.

As a further improvement, the vapours disturbing the action of the injection pump (to a lesser extent) are carried away. For this purpose the pipe " bye-pass II " is provided. The pipe is sufficiently small to avoid bubbles, forming in the vapour separator, being carried away, but is large enough to deal with the vapour bubbles forming continously in the injecting pump. The complete fuel conveying and injecting system is shown in Fig. 1.

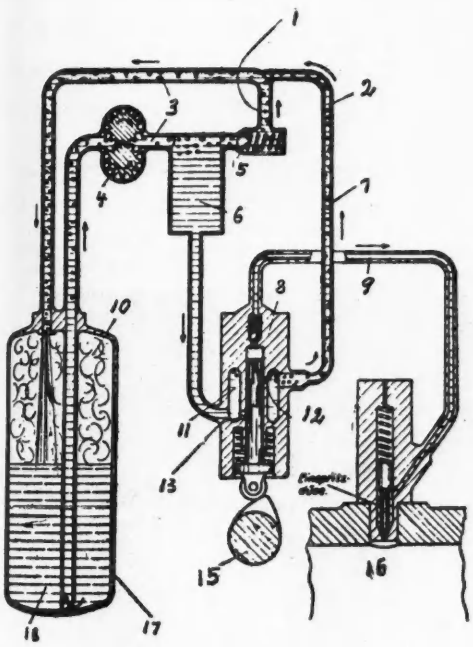


Fig. 1

(1) Vapour from separator; (2) Vapour from by-pass to injection pump; (3) By-pass II.; (4) Intermediate pump; (5) Safety valve; (6) Separator; (7) Throttle valve; (8) Injection pump; (9) Injection pipe; (10) Vapour; (11) Suction chamber; (12) Return channel; (13) Suction channel; (14) Injection jet; (15) Pump drive; (16) Combustion chamber; (17) Liquified gas container; (18) Liquid fuel.

The combustion of the liquified gases.

Fuels of this type have usually a very high octane number (100). Very irregular and violent ignition was obtained during the first experiments, the maximum pressure being about 160 kg./cm.^{2} Hence, it was found necessary to dope the fuel in order to increase the readiness for ignition. Ordinary lubricating oil was found to be very effective for this purpose, and this solution also provided the necessary lubrication to the pumps. On the small experimental engine it was found that 12% by weight of lubricating oil when mixed with the fuel gave satisfactory results. The performance of the engine could be further improved by suitably adjusting the time and period of injection. The pump employed was provided with a Deckel type of suction valve, which does not give sharp cut off or valve opening. The injection started slowly at the T.D.C.

By throttling the air intake, the engine could be easily started at low temperatures. This can be explained by the fact that the same air is compressed several times in the cylinders and thus heated to a higher temperature.

The particulars of the Junkers two-stroke experimental engine are as follows: bore: 65 mm.; Total stroke (opposed piston): 210 mm.; compression ratio: 15.4.1; R.P.M.: 1,450; Output: 12.5 HP. (100% load); Injection pump: Deckel PSF, 21, 13-7.5; Injection nozzle: Bosch DL 45, S 734; Length of injection pipe: 1,000 mm.; internal dia.: 1.5 mm.; Intermediate pump: Junkers three-cylinder pump. Excess pressure in the injection pump above the pressure in the fuel tank: 2kg./cm.^{2} Lubricating oil 12% by weight. Lowest starting temperature: +2° C.

Tables I and II show the relationship between the injection advance before the T.D.C. and the consumption for the two different types of fuels.

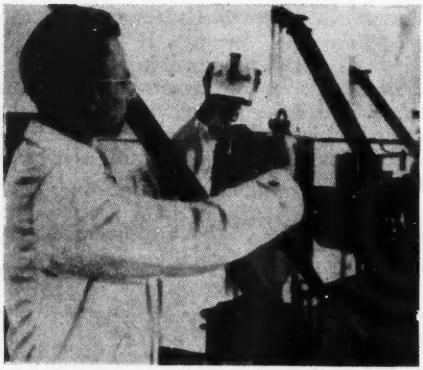


Fig. 2.
Testing apparatus to estimate the turbidity of exhaust gases.

The indicator diagram also gives the pressures when the fuel was cut off.

Fig. 2 shows the apparatus used to obtain the turbidity of the exhaust gases. The pro-

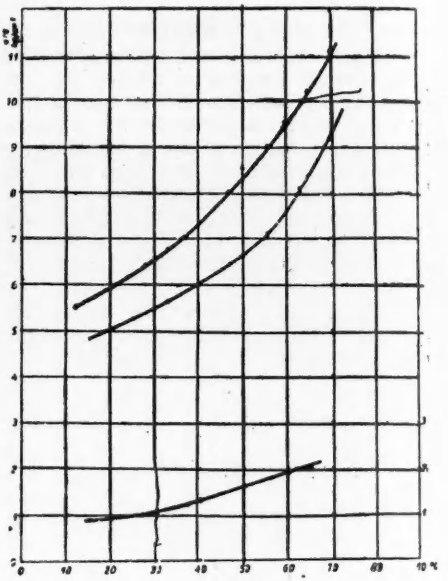


Fig. 3.

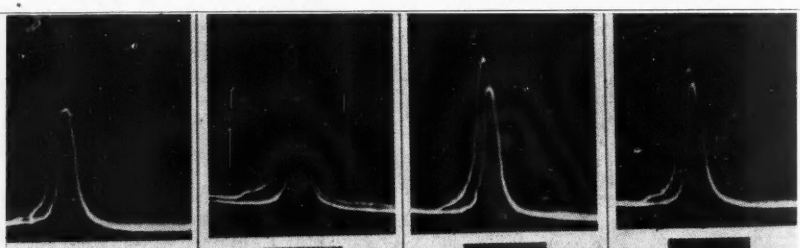
Gaseous fuel	N = 12.5 H.P.		n = 1450 R.P.M.	
Injection Advance	68.3°	64.3°	60.3°	56.3°
Indicator diagram				
Exhaust gas turbidity				
Ign. pr. / Compr. pr.	1.68	1.44	1.25	1.116
Fuel Consump.	2240	2300	2650	3170 Kcal/B.H.P. hour

TABLE I.

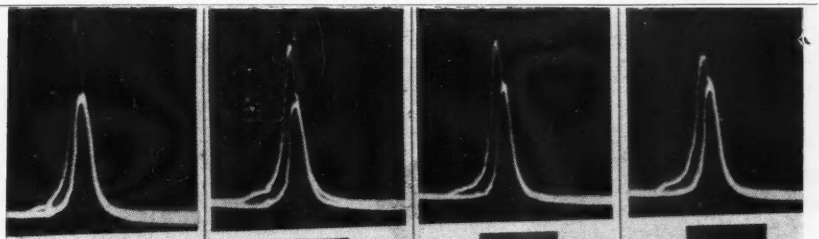
Liquified Gas	N = 12.5 H.P.		n = 1450 R.P.M.	
Injection Advance	84.3°	82.3°	80.3°	76.3°
Indicator diagram				
Exhaust gas turbidity				
Ign. pr. / Compr. pr.	1.68	1.52	1.405	1.28
Fuel Consump.	2230	2200	2280	2560 Kcal/B.H.P. hour

TABLE II.

cedure adopted was to expose a sheet of white paper to the effect of the exhaust gases.

From the Ignition pressure/compression pressure diagram it can be seen that the engine operates with the same mean pressure and fuel consumption if the ignition advance is increased by 15-16° in the case of the liquified gas fuel. Thus, it is possible to provide the engine with a very simple device to change it over from Diesel oil engine to an engine working with liquified gas.

During the actual operation of an engine, the pump is usually built together with the engine and hence becomes hot. An experiment during which the pump casing was artificially heated was carried out and the results are given in Fig. 3, showing the required fuel pressure in the intake chamber of the pump, corresponding to various temperatures of the pump casing. It can be seen that heating of the pump does not give rise to unexpected troubles.

From the results, the following constructional features can be concluded :

(1) Transmission of fuel to the injection pump must take place under higher pressure than the vapour pressure of the gas in the pump.

(2) Continuous pumping and circulation of the fuel to prevent the vapour bubbles reaching the pump.

(3) Simple device to vary the injection advance.

(4) Closed injection nozzle.

(5) Gradual slow starting of the injection.

(6) Addition of lubricating oil to the fuel.

THE IMPORTANCE OF PRODUCING FRESH WATER ON BOARD OF LARGE PASSENGER SHIPS

By R. BLAUM. (From *Schiffbau*, Vol. 41, No. 7, April, 1940, pp. 99-100.)

THE importance of producing fresh water on board of passenger ships becomes most eminent, when the distance between ports, where the water supply can be renewed, is large. As an example the Dutch ship "Oranje" (Stoomvaart Mij., Nederland Co.), a 20,000 t. passenger ship, with a crew of 380 and 747 passengers, is using up about 250-300 cu. m. of water per day. Shortly after the war had started the ship was cruising to the Dutch-Indies, and received orders to continue on its route to the Colombo round the Cape of Good Hope. During this 20-day voyage no port was entered, and the total water demand was produced on board of the ship. This was the first case in the history of shipping that a crew of 380 and 747 passengers were supplied with artificially distilled water, and no inconvenience whatsoever was experienced.

The general arrangement of the fresh water producing plant is given in Fig. 1. The evaporators are heated with steam, obtained from the gas boiler, which is using the exhaust gas of the 27,000 hp. main engines. For reasons of steam economy the plant is built up in three stages. Once started it operates automatically. The destillate of each evaporator is collected separately in one of the three cooling-containers (I, II, III), and the salt content is continuously checked by means of automatic recording instruments. The apparatus is able to deal with 25 cu. m. of sea-water per hour, producing 12.5 cu. m. of destillate per hour. The output of the water pump and the steam consumption is indicated on venturimeters (M_w and M_s). Since each cu. m. destillate is produced from twice as much sea-water and 0.470 t. of steam, the value

$$\frac{\text{sea-water consumed cu. m./hour}}{\text{steam consumed t/hour}}$$

must remain constant. Hence from the readings M_w and M_s it can be ascertained immediately if the apparatus is working properly.

The first stage of the evaporator needs cleaning after eight to ten weeks of operation, while the second and third stages only after about four months. The connection of the pipes is such that it can work in any combination of two stages, should the third one fail to operate.

The composition and taste of the water pro-

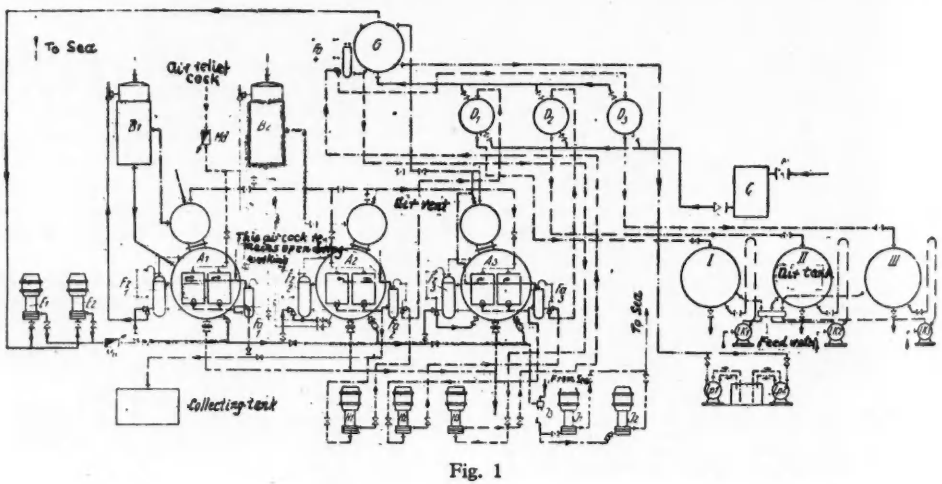


Fig. 1

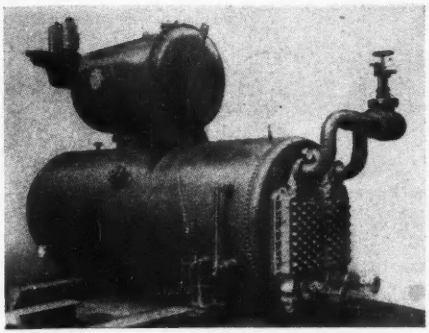


Fig. 2

duced is perfectly satisfactory in every respect, contrary to the water stored in tanks. The weight of the evaporator apparatus is 66 t. and the room occupied by the total water distillation system, including pipes and room to control and regulate the instruments, is only 461 cu. m. Adding to this 300 cu. m. for the volume of the reserve water tank, the total space occupied is only 761 cu. m. On the other hand the necessary volume taken up by water stored in tanks for a ten days' trip already exceeds this many times, since it is 3,300 cu. m. This means in other words, that the saving in the useful tonnage of the ship amounts to about 2,500 tons.

COMPRESSED AIR FOR STOPE FILLING

(From *Queensland Government Mining Journal*, Vol. 41, 15 October, 1940, p. 260.)

A SYSTEM which has been used with success in Broken Hill is the use of compressed air to blow mine residues and sand through pipes for the purpose of filling stopes. Under this pneumatic stowage method, sand or residue is blown from a central pass through pipes or hoses into position in the stopes or places to be filled. The apparatus used consists of a cylinder of 21 in. diameter, with a length of 6 to 12 ft., supported in an upright position under the lip of the sand pass. The upper portion of the cylinder is fitted with a hinged lid and the bottom is coned down to a diameter of 3 in. To this cone are attached the necessary pipes and noses to convey the sand to its destination. At intervals along the length of the cylinder pipe fittings are attached in order to permit the introduction of compressed air. Usually stope filling is done by shovelling. Owing to the peculiar circumstances, shovelling is often done in close and confined spaces, difficult both of access and of ventilation. In addition, the extraction of the last of the ore beneath any level, especially where the ore-bodies are of large dimensions, as is often the case in Broken Hill, is usually accompanied by more or less distortion and settlement of the level of the gangways. In some portions of the mines hydraulic stowage is now used, a method whereby the residues are conveyed by water through pipes from some central pass to their position in the stopes. The pneumatic method has been successfully used to fill inaccessible working and cavities, which, if left unattended, would eventually cause serious settlement or subsidence. It has been established that pneumatic filling is much more complete, as it ensures a tight fill.

MACHINE FASTENINGS IN DESIGN

By KENNETH D. MOSLANDER. (From *Machine Design*, Vol. 12, No. 12, December, 1940, pp. 51-53).

THE proper fastening, properly applied, is essential to fully satisfactory machine operation. Adequate consideration given to unusual conditions of shear, tension, compression or vibration in the specification of a fastening, will pay dividends in trouble-free operation of the finished machine or equipment. In what follows, information about the several types of machine fastenings available, as well as their applicability, will be described.

During recent years, a one-piece self-lock-

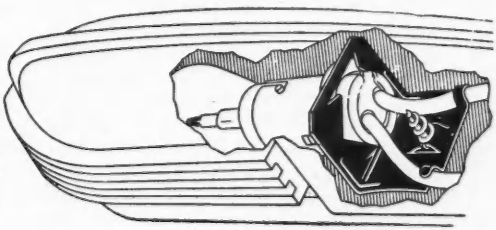


Fig. 1

ing nut, the principle of which is shown in Figs. 1 and 2, has attained increased prominence.

Basically, this nut is an arched spring steel stamping with integral prongs formed to meet the helical pitch of standard screw threads. As the screw is tightened, the base of the nut flattens out, exerting a tension force on the screw which provides a spring-locking action. At the same time, the prongs are thrust toward the screw gripping it tightly. The truss effect of the arched prongs in the locked position, provides the nut with holding qualities against tension.

This compound locking effect has a high vibration resistance as well.

Many different auxiliary features which facilitate assembly are capable of being incorporated integrally with the basic nut form. Fig. 2 illustrates one of these, known as the "heel and toe" attaching principle. A rectangular hole is formed in the lower plate adjacent to the screw clearance hole. The nut may then be snapped into this hole, thereby maintaining it in correct alignment with the screw and obviating the use of caged nuts.

Another type is the so-called J-nut, extensively used in fastening sheet metal panes, cowling, etc., where the screws are inserted close to the edge of the backing-up plate. The J-nut is snapped over the edge of the backing-up plate, thus holding the nut section in alignment with the clearance screws which are driven from the outside.

These fastenings are ordinarily made from spring steel strip containing from .7 to .8% carbon, although they are obtainable also for special applications of stainless steel, phosphor bronze or chrome molybdenum steel.

Several types of nuts are available with built-in auxiliary self-locking features which serve to hold the nut firmly to the bolt threads, even under the most severe conditions of vibration or tensile deformation of the bolt. In one of these a vulcanized fibre collar is spun into the top of the nut. This collar, being unthreaded, resists the entrance of the screw, thus automatically taking up all thread play and bringing the load-carrying thread surfaces of the nut and bolt into tight pressure contact.

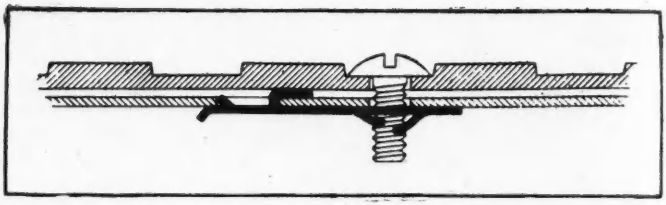


Fig. 2

Because of the resilient nature of the fibre, the nut may be removed and replaced repeatedly without loss of the locking action.

Due to the complete seal of the fibre ring around the male thread, these nuts may serve the auxiliary purpose on fluid containers and the like of preventing leakage past the fastening thread, as illustrated in Fig. 3.

Another nut capable of locking itself firmly to a standard bolt or stud is illustrated in Fig. 4. These nuts have an arcuate-shaped metallic locking ring spun into the face of the nut adjacent to the work. When the nut is screwed down tightly this ring is crushed flat, its inner edge gripping the bolt threads. This deformation is not elastic.

For corrosion resistent service, locking rings of duronze, everdur and monel are available. Since the nuts are all metal, they are unaffected by heat or moisture met with in nominally severe service.

A type of self-locking nut is one which, upon tightening, closes around the male thread with a vibration-resistant grip. The inner bearing surface of this nut is recessed so that the entire bearing load is carried on an outer annular bearing surface. The opposite end of the nut has six narrow longitudinal slots extending through the centre of the flats of the hexagon.

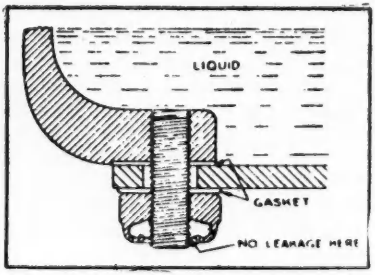


Fig. 3

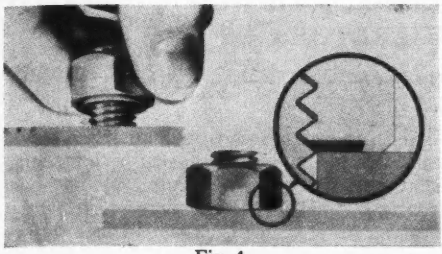


Fig. 4

When tightened down, the re-action of the work against the bearing ring creates a couple with the thread thrust, causing the slotted upper sections of the nut to close in on the bolt or stud. This elastic deformation of the nut imposes a positive tension in the bolt and also results in a more complete distribution of load on the engaged threads. Fig. 5 illustrates an application of these nuts in fastening the connecting rod bearing caps of a Pontiac engine.

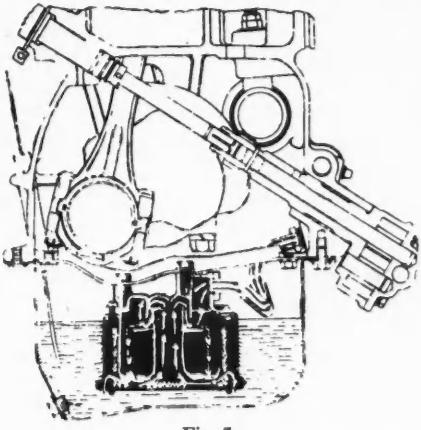


Fig. 5

Designed to achieve locking action between the male and female threads, without the use of springs or other auxiliary gripping devices, the special thread form illustrated in Fig. 6 locks in the final quarter turn of the nut or cap screw. The root of the male thread is formed in two concentric frustroconical steps, each tapering at an angle of six degrees. The female thread is tapered at a similar angle to engage by a wedge fit the outer step when the re-active pressure of the work on the nut or screw head forces these two surfaces together. In this position, positive locking of the threads is attained, not only under conditions of vibration and elastic elongation of the screw, but also under rotational tendencies of the work in relation to both the bolt and nut.

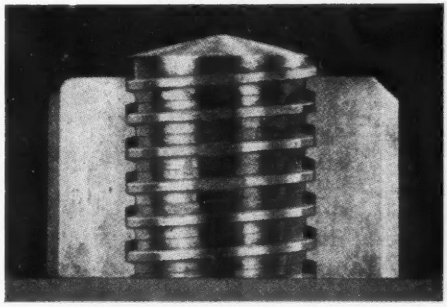


Fig. 6

Intimacy with which the threads are engaged in the locked position has led to a further rather interesting use in electrical service. In applications where these fastenings have an auxiliary function as an electrical terminal, laboratory research has determined that they possess 80% less electrical resistance across the threads than conventional screws.

EFFECT OF SPEED OF PULLING JAWS ON TENSILE STRENGTH AND STRETCH OF LEATHER

(From *Technical News Bulletin of the National Bureau of Standards*, Washington, August, 1940, No. 280, p. 68).

THE importance of measurements of tensile strength and stretch of leather is indicated by the fact that 10 of the 12 Federal specifications for different types of leather include requirements for these properties. In measuring the strength of leather, the speed of the jaws of the testing machine affects the results. In practice, speeds of the pulling jaws as low as 0.25 in./min., and as high as 12 in./min. are being used in different laboratories.

About 1,900 measurements of tensile strength and stretch were made at six jaw speed from 0.5 to 20 in./min. using a horizontal Scott machine of the pendulum type, having a capacity of 800 lb. The effect on stretch at breaking load was erratic; the average difference between the stretch at 0.5 and that at 20 in./min was only 1%, which is no larger than the smallest interval read in the measurements of stretch. The tensile strength increased as the speed of the jaws increased. The rate of increase was smallest between speeds of 6 and 12 in./min.

BOILERS WITH MOVING GRATES FOR CENTRAL HEATING PLANTS, TYPE ROUCKA

BOILERS with moving grates were introduced in Czechoslovakia for central heating a few years ago. The velocity of the moving grates were controlled by a thermostat. The experiences of the last few years proved that the expectations of the manufacturers were fulfilled, the efficiency of the boilers being very high and, therefore, a further development of this type of boiler is to be expected.

One of the first boilers with moving grate and thermostatic control, specially designed for central heating plants, was constructed by E. Roucka Engineering Co., in Blansko. To ensure a good combustion of gassy fuels, like the Bohemian bitumenous coal, an internal firebox was arranged, which was divided into two parts by an arch made of firebricks. The firebox forms a separate unit, and consists of a water jacket. The flue gases are guided from the rear to the front smoke chamber, and from there they are conveyed to the smoke box at the back of the boiler. Both, the firebox and the smoke pipes are covered with an insulating jacket. For the induced draught a fan was employed.

Later types of boilers were constructed with the smoke pipes arranged vertically, or using water tubes instead of smoke tubes, the main principle of the boilers, however, remaining unchanged.

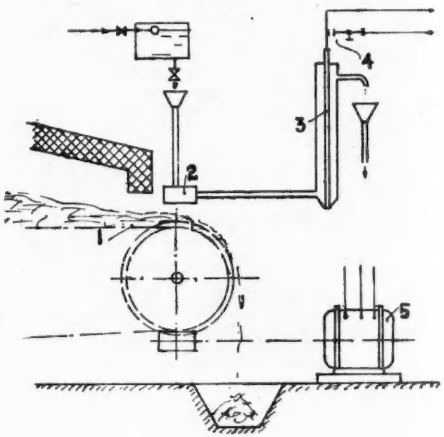


Fig. 1

The original automatic thermostatic control of the boiler grates is rather interesting. The movement of the grate was controlled by the heat requirement of the plant and by the temperature of the fuel at the rear of the grate.

The flue gases were kept at a temperature of about 150° C. A scheme of the control is shown in Fig. 1.

A heater fitted above the rear of the grate is kept full with water by using a control valve. The temperature of the water in the heater corresponds to the temperature of the rear of the moving grate. The water flows from the heater into a vessel in which a heat sensitive strip provided with an electric contact is arranged. If the water entering this vessel is not sufficiently warm the electric contact is closed and starts the motor driving the grate. No sooner the water is heated by burning coal reaching the end of the grate, the motor is stopped again.

A complete arrangement of the boiler control designed by the Skoda-Works is shown in Fig. 1, the principle of operation being unchanged, but air instead of water is used as medium. Air is blown through a duct into a small heating element placed at the rear of the moving grate. The dampers in the primary and secondary inlet and in the flue stack are controlled by the pressure and the flow in the steam or water boilers respectively. A further control is arranged by a thermostat controlled by the flue gas temperature at the rear of the

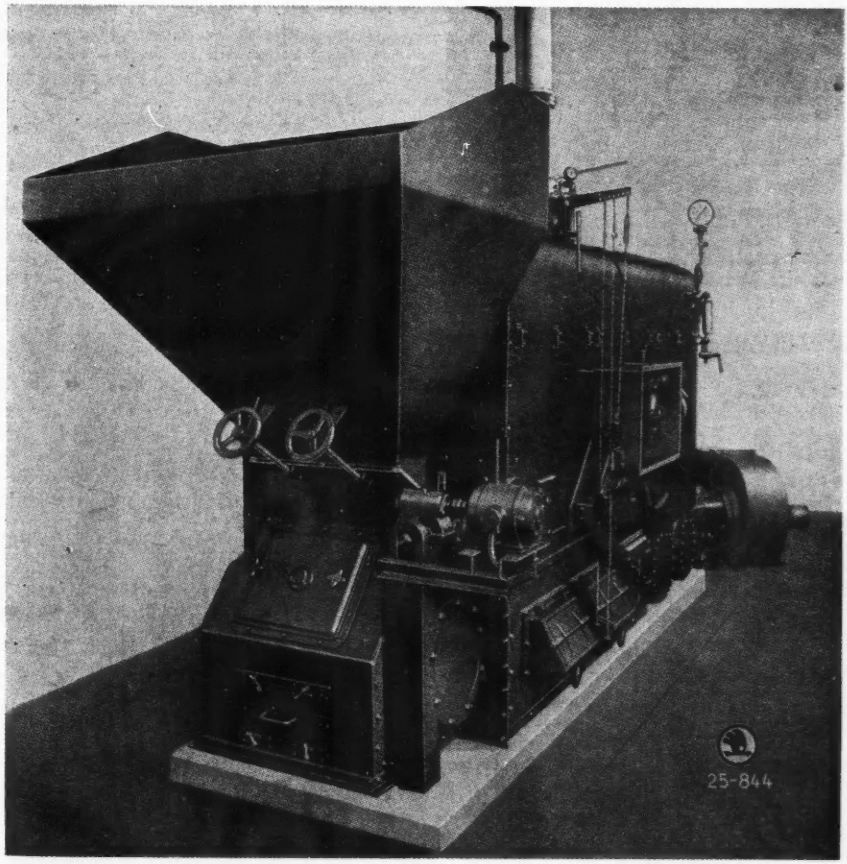


Fig. 2

Low-pressure boiler, system "Skoda," with automatic regulator for Central Heating Plant.

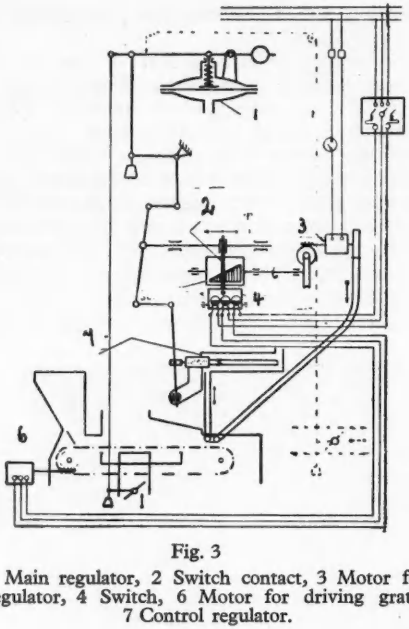


Fig. 3

1 Main regulator, 2 Switch contact, 3 Motor for regulator, 4 Switch, 6 Motor for driving grate, 7 Control regulator.

Fig. 4

Section through low-pressure boiler "Skoda."

grate. The speed of the motor driving the grate can be varied by a regulator.

The motion of the grate is thus intermittent and the intervals of running are controlled.

An average boiler efficiency of 80% was obtained with very cheap fuel.

HIGH PRESSURE STAMPING

(From *Werkstatt und Betrieb*, Vol. 73, No. 4, April, 1940, page 80).

ELASTIC material machine tools are employed in ever-increasing numbers. Fig. 1 shows the schematic arrangement of a rubber stamping machine for pressing and drawing. Only the bottom part of the pressing block need to be shaped according to the work. This may, in many cases, consist of a cast iron block and does not need very accurate finishing. If it is used for pressing light metal, then inserting and removing from the press is very simple indeed.

Fig. 2 shows a large rubber press for works up to 2 m. dimensions. The press has four columns, and each half of the press can be moved separately. The line of partition can be seen on the figure between the two columns.

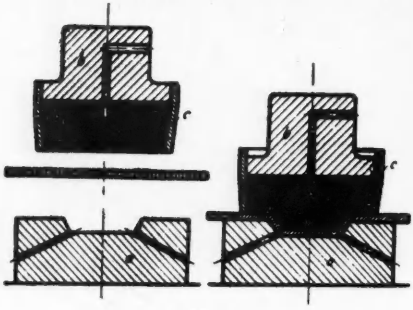


Fig. 1

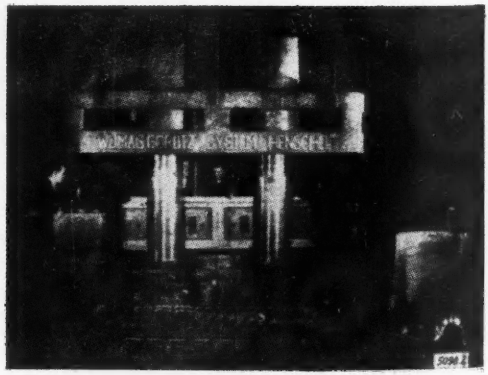


Fig. 2

INVESTIGATION OF THE CAUSES OF GRAIN-BOUNDARY CORROSION IN HARDENED ALLOYS, OF THE AL-CU-MG TYPE

By M. BOSSHARD. (From *Schweizer Archiv*, Vol. 6, No. 10, October, 1940, pages 265-279.)

THE Al-Cu-Mg alloys include the most important types of alloys used in the aircraft industry. The hardened alloys (hardened by heat treatment) should be corrosion resistant. In practice, two types of corrosion of these metals have been observed: ordinary corrosion, causing corroded spots, holes, or blisters filled with the products of corrosion, and intercrytalline corrosion in which the attack follows the grain boundaries. This latter type of corrosion is very difficult to detect and is, therefore, very dangerous and should be eliminated. (The two types of corrosions are shown in Figs. 1 and 2).

Investigations, so far carried out, do not sufficiently explain the reasons for grain-boundary corrosion. In the following a systematic investigation on this subject will be described, which was carried out by the Aluminium-Industrie AG., Neuhausen.

Two alloys, the Avional D and the Avional Z, were used during the tests, which have the following compositions:

	Avional D	Avional Z
% Cu	3.8	4.5
% Mg	0.5	0.8
% Mn	0.5	0.7
% Si	0.3	0.5
% Fe	0.3	0.3

Avional D has a much stronger tendency towards corrosion than Avional Z.

For the purposes of investigation the hardened alloys were corroded either in salt spray baths or in a normal solution of NaCl to which 1% hydrochloric acid was added. The second method is much quicker than the first method, and is very suitable for the purpose of investigation.

The heat treatment of the 1 mm. thick sheet metals used during the experiment consisted

Fig. 1

Magnification 150x. Local corrosion on an 1 mm. Avional D sheet metal, corrosion in salt spray bath: 3 months.

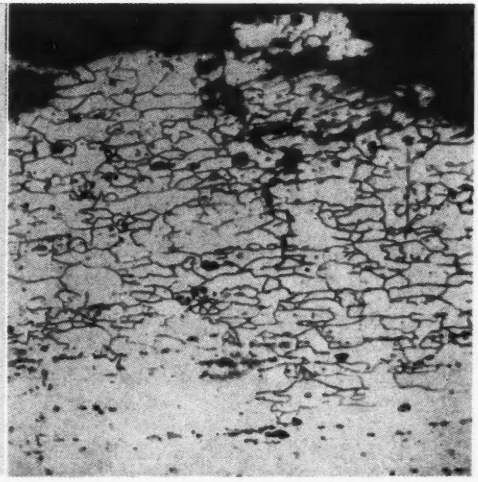


Fig. 2

Magnification 150x. Grain boundary corrosion on an 1 mm. Avional D sheet metal, corrosion in salt spray bath: 3 months.

of heating at about 500° C for 60 min. in either air or a salt bath, quenching in water at 15-20° C. The samples were allowed to stand for about 5-10 days, after which they were examined.

Influence of the Medium of the Heating Bath.

This has no influence on the type of corrosion. Great differences in the amount of corrosion taking place were, however, observed as shown in Table I. The far greater amount of losses in strength and percentage elongation in case of the air bath compared with those in the case of heating in the salt bath, are most probably due to the preliminary corrosion taking place in the air bath, under the action of hot air on the crystals containing magnesium. The preliminary corrosion is then rapidly promoted in the salt spray bath. This theory is also supported by the fact that the surface of the sheet metal shows a distinct alkali reaction caused by the presence of magnesium oxide. The difference between the effects of the medium in which the alloy is heated is further increased with increasing magnesium content.

TABLE I.

Corroded in salt spray bath	Heat treated in air 2 hours: Tensile strength Kg/mm²	% Elong.	Dec. in % Elong. (%)	Heat treated in salt bath 30 mins.: Tensile strength	% Elong.	Dec. in % Elong. (%)
Uncorroded	43.2	19.6	—	43.0	22.5	—
Corroded ½ month	41.0	13.8	30	41.8	20.4	9
„ 1 month	39.5	10.4	47	40.2	16.2	28
„ 2 months	33.6	5.5	72	36.8	12.0	47
„ 3 months	29.4	2.7	86	34.5	8.0	64

Influence of Temperature of Heat Treatment.

Variation of the temperature within the region of 450° to 540° C, has only a slight effect on the corrosion. Intercrystalline corrosion could only be observed with the lowest temperatures.

Influence of the Duration of the Heat Treatment.

Samples were heated in the air bath and in the salt bath for 10, 30, 60, 120, and 300 minutes, and after six days they were corroded at room temperature. No differences on the samples of Avional D could be observed, but Avional Z showed intercrystalline corrosion with the shortest and longest heat treatments. It seems that an improvement is obtained with prolonged heat treatment as far as percentage elongation is concerned.

TABLE II.

(Heat treated in salt bath for 30 minutes, quenched and allowed to stand at 20°C. for 5 days).

Temp. of Heat Treatment	Corrosion in months	Tens. Strength kg/mm²	% Elong.	Decrease in % Elong.
450°C	0	39.5	22.0	—
	½	39.0	20.1	8.5
	1	38.2	16.2	26.0
	2	37.3	11.5	48.0
	3	36.5	10.0	55.0
475°C	0	41.0	22.8	—
	½	40.8	21.0	8.0
	1	40.0	18.8	17.5
	2	37.7	13.5	41.0
	3	36.0	10.2	55.0
500°C	0	43.1	23.0	—
	½	42.0	21.1	8.0
	1	40.5	18.2	21.0
	2	39.0	12.8	44.5
	3	35.5	10.1	56.0
520°C	0	43.0	22.5	—
	½	41.8	20.4	9.0
	1	40.2	16.2	28.0
	2	36.8	12.0	47.0
	3	34.5	8.0	64.5
540°C	0	42.5	22.0	—
	½	41.5	18.0	18.0
	1	40.0	14.8	33.0
	2	36.4	10.2	53.5
	3	34.0	6.7	69.0

Influence of Pre-cooling.

By pre-cooling, is understood the cooling which takes place between the withdrawal of the sample from the furnace and putting it in the quenching medium. As the drop in temperature during this period is very difficult to measure, the time elapsing between the two instances is measured instead.

It was found from the experiment that pre-cooling is the most important factor affecting the quality and quantity of corrosion which might take place in the metal. Experiments with pre-cooling of 1, 10, 20, 30, 60, and 120 secs. were carried out. Each test sample showed that while a short period of pre-cooling produced only ordinary corrosion attacks, the prelongation of the pre-cooling caused intercrystalline corrosion (see Figs. 3 to 7). Results of a test on a series of Avional D alloy with pre-cooling of 2 and 40 secs. is given in Table III.

Fig. 3

Magnification 60x. Avional Z sheet metal, heated for 30 min. in salt bath at 490 °C. Precooling 1 sec., quenched in water at 20 °C. Corrosion in acidic salt bath : 3 days.

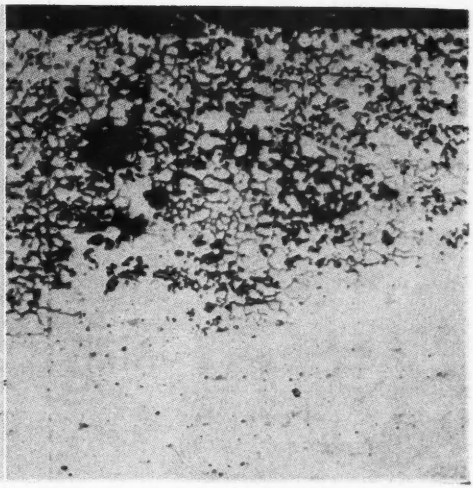


Fig. 5

Magnification 60x. 1 mm. Avional Z sheet metal, heat treatment and corrosion as in Fig. 3, precooling 20 sec.

The fractured parts, resulting from the tensile strength determination, are shown in Fig. 8. Note that samples C and E do not show transversal contraction. Sample C was corroded at both sides to a depth of about 1/4 of the thickness, the inner part remaining intact. On sample E corrosion took place almost down to the centre of the specimen.

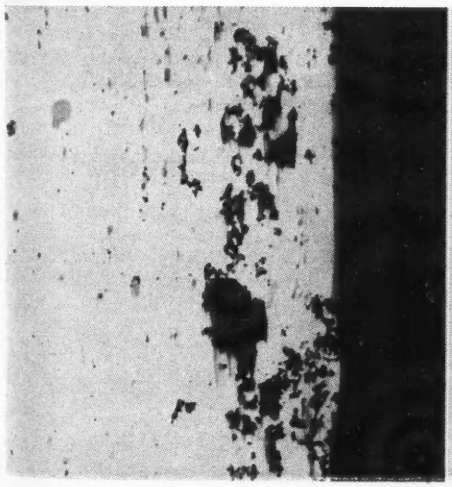


Fig. 4

Magnification 60x. 1 mm. Avional Z sheet metal, heat treatment and corrosion as in Fig. 3, precooling 10 sec.

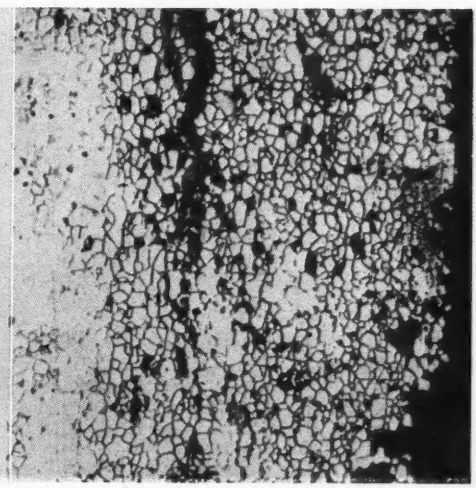


Fig. 6

Magnification 60x. 1 mm. Avional Z sheet metal, heat treatment and corrosion as in Fig. 3, precooling 60 sec.

Results of the examination of physical properties after corroding the samples in salt bath, are given in Table VI.

TABLE III.

Specimen	Heat treatment	Time of precooling	Corrosion treatment	Tensile strength	% Elong.
A	30′ salt bath, 515°C	2″	uncorroded	40.9	21.8
A1	„ „ „ „	40″	„	39.7	22.0
B	„ „ „ „	2″	6 h. NaCl + HCl	39.8	20.3
C	„ „ „ „	40″	„ „ „	21.4	7.2
D	„ „ „ „	2″	„ „ „	39.5	15.2
E	„ „ „ „	40″	„ „ „	4.4	0.2

TABLE IV.

Alloy	Corrosion period in months	5 secs. Tensile strength kg/mm²	% Elong.	Precooling 20 secs. Tensile strength kg/mm²	% Elong.	40 secs. Tensile strength kg/mm²	% Elong.
Avional D	0	41.5	20.9	41.1	21.5	40.9	20.7
„	1	39.6	14.6	36.7	9.1	33.6	7.2
„	3	35.8	9.7	31.1	5.6	17.2	2.0
Avional Z	0	46.8	20.6	46.5	19.3	45.5	20.2
„	1½	44.5	13.2	38.1	10.3	32.4	5.5

Influence of the Quenching Medium and Temperature.

Experiments with quenching in water at 4, 20, 50, and 100° C as well as in oil at 30° and 60° C were carried out. In each case the test pieces were corroded in acidic solution of NaCl for three days. Figs. 9 to 12 show the result of the microscopic examination. It can be seen that quenching in water results in heavier grain-boundary corrosion, the higher the water temperature is. The reversed result obtained with quenching in oil at 30° and 60° C, may be due to the reduced viscosity of oil at higher temperatures, and hence more effective quenching.

Results of the changes in physical properties are tabulated in Table V.

TABLE V.

(Corroded in salt spray bath).

Quench'g medium	Quench'g temp.	Uncorroded Tensile strength kg/mm²	% Elong.	1 month Tensile strength kg/mm²	% Elong.	3 months Tensile strength kg/mm²	% Elong.
Water	4°C	40.7	22.0	38.8	11.8	34.1	7.7
„	20°C	40.9	21.2	38.0	12.0	31.0	6.5
„	50°C	41.1	21.8	37.5	11.1	31.4	6.7
„	100°C	42.0	22.5	32.7	8.2	30.1	4.6
Oil	30°C	40.9	22.5	31.7	6.2	28.8	4.5
„	60°C	41.0	23.0	36.0	9.0	31.2	5.5

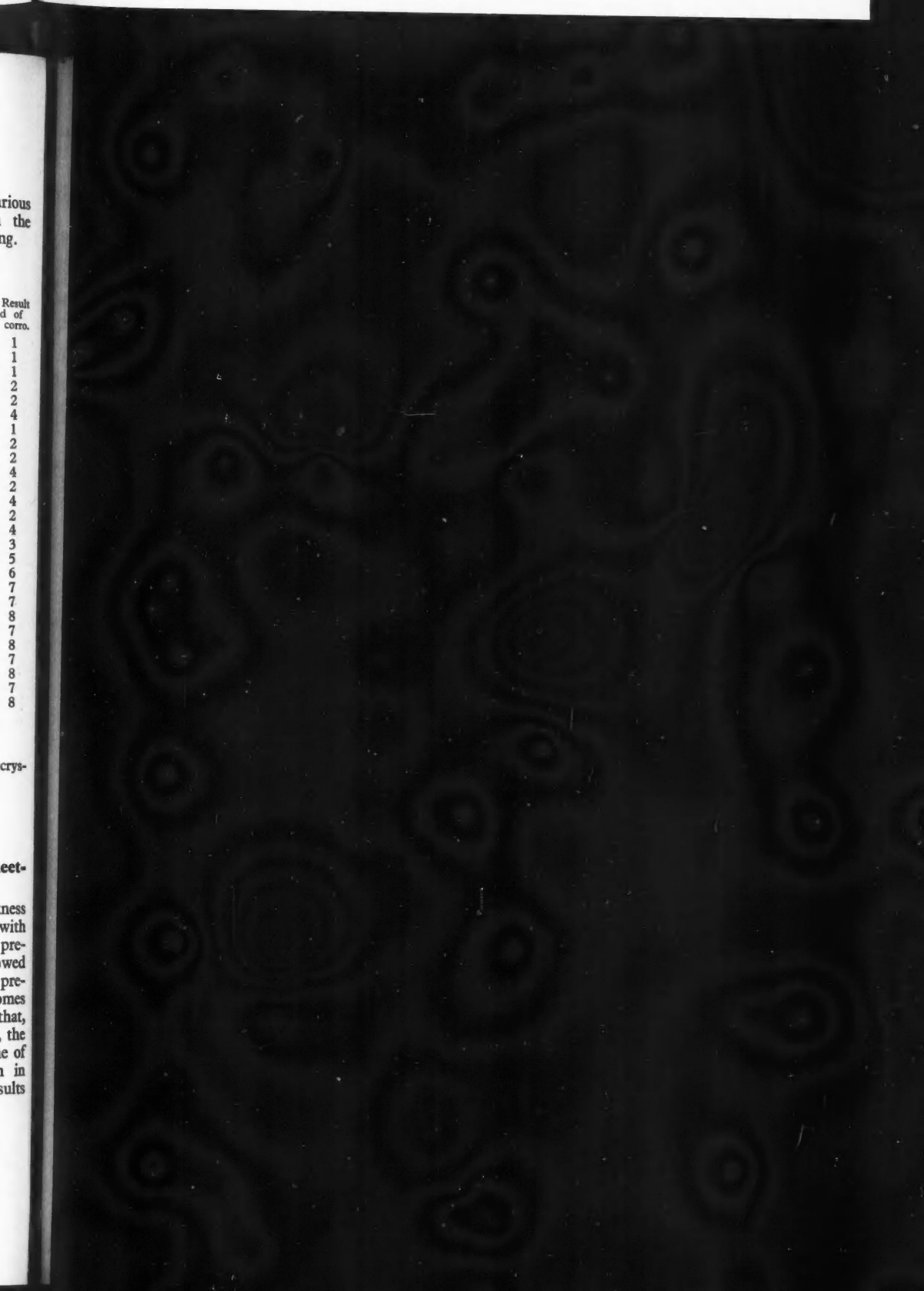
Table VI. shows the influence of various temperatures and times during which the specimen is allowed to rest after quenching.

TABLE VI.

No.	Temp.	Heat Treatment time	Pre-cooling in secs.	Hardening temp.	Time	Corroded in hrs.	Result of corro.
L	510	30′	2″	—	—	72	1
2	510	30′	20″	—	—	72	1
3	510	30′	2″	0	10 d.	72	1
4	510	30′	20″	0	10 d.	72	2
5	510	30′	2″	20	5 d.	72	2
6	510	30′	20″	20	5 d.	72	4
7	510	30′	2″	20	30 d.	72	1
8	510	30′	20″	20	30 d.	72	2
9	510	30′	2″	40	2 d.	72	2
10	510	30′	20″	40	2 d.	72	4
11	510	30′	2″	40	5 d.	72	2
12	510	30′	20″	40	5 d.	72	4
13	510	30′	2″	40	30 d.	72	2
14	510	30′	20″	40	30 d.	72	4
15	510	30′	2″	80	2 d.	72	3
16	510	30′	20″	80	2 d.	72	5
17	510	30′	2″	130	1 d.	6	6
18	510	30′	20″	130	1 d.	6	7
19	510	30′	2″	160	1 d.	6	7
20	510	30′	20″	160	1 d.	6	8
21	510	30′	2″	220	8 h.	24	7
22	510	30′	20″	220	8 h.	24	8
23	510	30′	2″	300	6 h.	24	7
24	510	30′	20″	300	6 h.	24	8
25	510	30′	2″	350	4 h.	24	7
26	510	30′	20″	350	4 h.	24	8

(1) = sporadic local corrosions.
(2) = fairly strong local corrosions.
(3) = many heavy local corrosions.
(4) = local corrosion with transition to intercrystalline corrosion.
(5) = local and intercrystalline corrosions.
(6) = weak intercrystalline corrosions.
(7) = strong „ „
(8) = very heavy „ „

Influence of the Thickness of the Sheet-Metal.

Samples of 0.5, 1, 2, 3, and 5 mm. thickness were examined. Each sample was tested with 1-3 and 40 secs. pre-cooling. With short pre-cooling times, only the thin test pieces showed intercrystalline corrosion. With 40 secs. pre-cooling, the intercrystalline corrosion becomes much stronger. Generally, it was found that, with decreasing dimensions of the sample, the tendency to corrosion is increasing. Some of the sections, after corrosion, are shown in Figs. 13-17, while Table VII. shows the results of the effect on the physical properties.

(*To be continued*).